

POOLEY'S<sup>TM</sup>

# CRP-5

COMPUTER HANDBOOK

*for the*

# CRP-5 & 5W

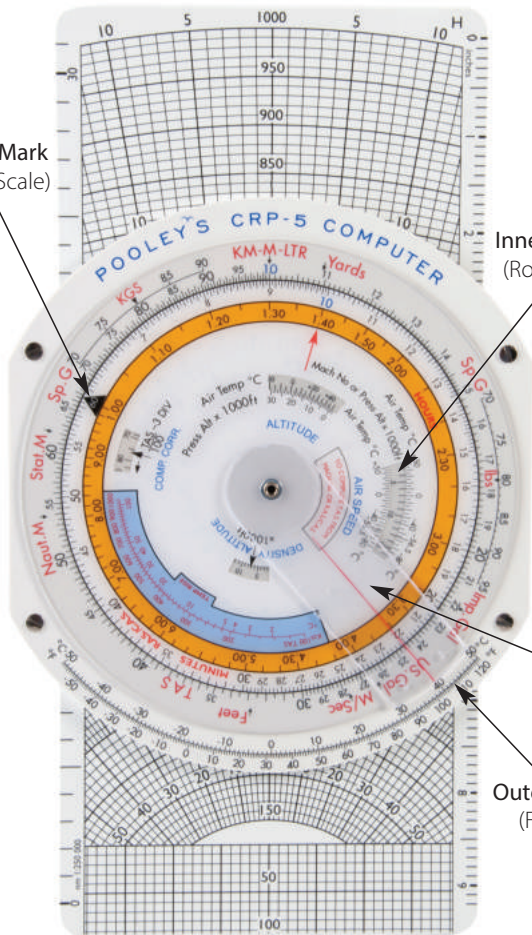


Index Mark  
(Inner Scale)

Inner Scale  
(Rotating)

Cursor

Outer Scale  
(Fixed)



# INDEX

*Page*

Foreword	2
Introduction	3
The Circular Slide Rule	4
Ratios	6
Conversions	8
Speed, Distance and Time	12
Calculation of TAS	16
Temperature Rise Scale	20
Minutes to Hours and Minutes Scale	21
Calculation of True Altitude	21
Calculation of Density Altitude	23
Drift/Variation and True Heading Index	25
The Slide	27
The Triangle of Velocities	27
To Check WV at a Turning Point	34
To find Head and Cross Wind Components	35
CRP-5W–Wind Bar	37

POOLEYS FLIGHT EQUIPMENT LIMITED

Tel: +44(0)208 207 3749 | Fax: +44(0)208 953 2512

Email: [sales@pooleys.com](mailto:sales@pooleys.com)

---

# FOREWORD

---

The Pooleys CRP Computers have been designed to supply a World Aviation Market with the finest Air Navigation Computers that can be made.

The **CRP-5, 5W Computers** have been designed for **Commercial Aviation Students and Pilots.**

Our computers are made of the best materials available and are guaranteed to withstand temperatures up to 60°C. They are stable, non-inflammable and resistant to mould and moisture. Every care is taken in manufacture to ensure that the resulting product is a high precision instrument both in accuracy and durability.

**To maintain clarity and ensure maximum life, do not allow chemicals and particularly solvents to come in contact with the computer ie. nail varnish remover.** The computer should not be exposed to extreme of temperature and should be protected from prolonged exposure to sunlight. It is better to mark the computer, when this is necessary, with a pencil as this can be easily erased with a soft rubber. Wiping off Chinagraph marks eventually destroys the clarity of the window.

Your computer is guaranteed against defective materials and workmanship and will be replaced free of charge should such faults occur. We trust that your Pooleys Computer will give you satisfactory service.

*Robert Pooley*

---

# INTRODUCTION

---

The 1988 models of this range of CRP computers incorporate several changes from previous models. Heavier grade materials are now employed in their construction, the obsolete pressure pattern latitude scale has been deleted and the slide now has graduations along the edges for measuring in inches, millimetres and nautical miles (to scales of 1:250,000 and 1:500,000). Minor changes to the layout and clearer numerals make for easier reading and use.

The various ways of using the computer described in this handbook, particularly the solving of triangle of velocity problems, are those employed in Commercial Aviation. These ways of usage, evolved from vast experience and knowledge of the problems involved are consistent in their application and solve all known problems. Many alternative ways of solving problems on the computer exist; mostly they are one-off solutions involving non-standard use of datums. In experienced hands "short cuts" may be acceptable but newcomers are strongly advised not to try them as the end result is usually confusion and frequently they are left with long term hang-ups about the computer.

---

# CRP-5 & 5W COMPUTERS

---

Although this range of computers is designed for **Commercial Pilots** they are also popular with **Private Pilots**. Since this latter group do not always have ready access to experience instructors this handbook includes brief backgrounds to some of the navigation problems which are not always clear to the newcomer to flying.

In this age of the electronic calculator many people are unfamiliar with slide rules, so a very brief primer of the use of the circular slide rule is also included.

*The computers have two sides:*

**Side 1.** A circular slide rule which incorporates windows and indices for solving problems peculiar to aviation.

*(See inside front cover)*

**Side 2.** The CRP-5 has a rotatable window disc and a double sided, low speed and high speed, slide for solving triangle of velocity problems. There is also a drift/variation scale with a central index mark. *(See inside rear cover)*

The CRP-5W is similar to the CRP-5 but also has a wind arm.

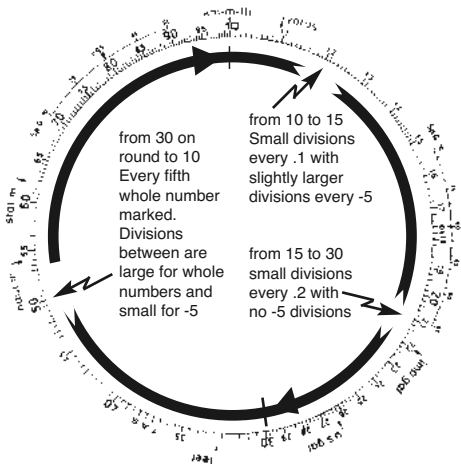
---

## SIDE 1: The Circular Slide Rule

---

Basically this is a device for solving ratio problems. Although based on logarithms there is no need for the user to have any knowledge of the theory behind logarithms. However there are two aspects of the scale spacing and the numbering that need to be clearly understood.

**SPACING** The scale is not constant and the values of the various divisions are clarified on the diagram below.



**NUMBERING** The actual numbers printed go from 10 to 95, with some omissions due to compression of the scale. By use of the cursor and the graduated scale it is possible to select any value from 10 to 99.9 but since there are only whole numbers printed on the scale any decimal point has to be mentally inserted. This gives great flexibility, for by mentally moving the decimal point to the right or left a position on the scale can be used to represent a whole range of numbers. For example the second small division to the right of 17 can be used to represent 17.4; 1.74; 17400; 0.00174 etc.

When performing calculations on the circular slide rule particular care has to be taken in the positioning of the decimal point in the final answer. Experienced users **always** carry out a rough calculation to establish an approximate answer **before** actually programming the circular slide rule. This procedure is demonstrated in examples in this handbook.

---

# RATIOS

---

Any relationship that can be written in the form  $P/Q = A/B$  can be set on the circular slide rule thus



Provided any three are of known values the circular slide rule will solve for the fourth value.

**Example:** In the above ratio if  $P = 25$ ,  $Q=8$  and  $B = 9.5$   
What is the value of  $A$ ?

*Rough Check:* 25 is approximately  $3 \times 8$  therefore  $A$  must be approximately  $3 \times 9.5$  or  $= 28.5$

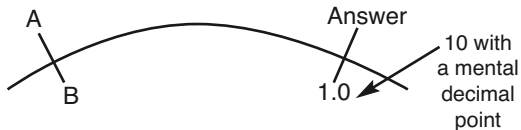
## SET SLIDE RULE



*Rough answer 28.5, therefore actual answer 29.7 (and not 2.97 or 297)*

## DIVISION

$A$  divided by  $B$  can be written  $A/B = \text{Answer}/1$ .  
On the circular slide rule this is set thus



*Example:*  $462 \div 17.9$   
*Rough Check* say,  $500 \div 20 = 25$



**SET SLIDE RULE**

*Rough answer 25, therefore actual answer 25.8 (and not 258).*

**MULTIPLICATION**

A multiplied by B can be written as  $A/1 = \text{Answer}/B$ .  
On the circular slide rule this is set thus:



*Example:*  **$0.015 \times 0.26$**

*Rough Check:* Say,  $0.02 \times 0.2 = 0.004$

**SET SLIDE RULE**

*Rough answer 0.004, therefore actual answer 0.0039  
(and not 0.039 or 0.00039).*

In both division and multiplication the 10 (used as 1.0) played a key role as a constant. Because of its frequent use as a constant it has been highlighted in blue on both the inner and outer scales.

---

# CONVERSIONS

---

The relationship between different units of measurements are fixed ratios, ie. 1 Imperial Gallon = 4.54 litres. This means the circular slide rule can be used to solve conversions.

Printed in *red* around the outer scale are various datums for units of length, volume and weight used in aviation. (*See inside front cover*). By aligning a known quantity on the inner scale of the circular slide rule with the datum mark for its units, its equivalent quantity in alternative units of measurement can be found by reading in from the alternative unit datum mark.

## CONVERSION BETWEEN METRES, YARDS & FEET

The rough conversion factors for checking purposes is 1 metre = 3.3 feet.

**Example:**      **How many feet are there in 4727 metres?**

*Rough Check:*       $3.3 \times 4700 = 15000$  feet

### SET SLIDE RULE

Align 4727 on the inner scale with the red **M** datum (at 10 on the outer scale). Put the cursor through the red **feet** datum (near 33 on the outer scale) and read off 15500 feet on the inner scale. At the same time opposite the red **Yards** datum mark will be found 5160 yards on the inner disc. Note yards are seldom used in aviation.

The rough check of 15000 feet was used to decide the value of 15500 feet as the correct answer.

## CONVERSIONS BETWEEN NAUTICAL MILES, STATUTE MILES & KILOMETRES

The rough conversion factors for checking purposes are  $1\text{nm} = 1.2\text{st.m.} = 2\text{km}$ , these are slightly higher than actual values but good enough for establishing where the decimal point goes in the answer.

**Example:** Convert 2650 km to nm and st.m

*Rough Check:*  $2650 \div 2 = 1300\text{nm} = 1560\text{st.m}$

### SET SLIDE RULE

Align 2650 on the inner scale with the red **km** datum (at 10 on the outer scale). Put the cursor through the red **naut.m** datum (near 54 on the outer scale) and read off 1430nm on the inner scale, then put the cursor through the red **stat.m** datum (near 62 on the outer scale) and read off 1640 stat.m on the inner scale. The rough checks having ensured that the final answers must be in the region of 1500.

## CONVERSION BETWEEN KNOTS, MPH & KPH

Since knots (kt) are nautical miles per hour, mph are statute miles per hour and kph are kilometres per hour the same datums and rough conversion factors are used as for the distance conversion.

**Example:** Convert 363 kt to mph and kph

*Rough Check:*  $360\text{kt} = 432\text{mph} = 720\text{kph}$

### SET SLIDE RULE

Align 363 on the inner scale with the red **naut.m** datum. Put the cursor through the red **stat.m** datum and read off 419 mph on the inner scale, then put the cursor through the red **km** datum and read off 673 kph on the inner scale.

## CONVERSION BETWEEN IMPERIAL GALLONS, US GALLONS & LITRES

The rough conversion factors for checking purposes are  
 $1 \text{ Imp gal} = 1.2 \text{ US gal} = 4.5 \text{ ltr}$ .

**Example:** Convert 25200 ltr to Imp gal and US gal

*Rough Check:*  $25000 \text{ ltr} = 5500 \text{ Imp gal} = 6600 \text{ US gal}$

### SET SLIDE RULE

Align 25200 on the inner scale with the red **ltr** datum (at 10 on the outer scale). Put the cursor through the red **Imp gal** datum (at 22 on the outer scale) and read off 5540 Imp gal on the inner scale, then put the cursor through the red **US gal** datum (at 26.4 on the outer scale) and read off 6650 US gal on the inner scale.

## CONVERSION BETWEEN KILOGRAMS & POUNDS

The rough conversion factor for checking purposes is  $1 \text{ kg} = 2.2 \text{ lbs}$ .

**Example:** Convert 4290 lbs to kgs

*Rough Check:*  $4400 \text{ lbs} \div 2.2 = 2000 \text{ kgs}$

### SET SLIDE RULE

Align 4290 with the red **lbs** datum (at 80 on the **Sp.G** scale between 15 and 21 on the outer scale). Put the cursor through the red **kgs** datum (at 80 on the **Sp.G** scale between 70 and 90 on the outer scale) and read off 1940 kgs on the inner scale.

## CONVERSIONS BETWEEN VOLUMES & WEIGHTS

These conversions employ the volume datums and the two Sp. G. scales mentioned in two previous conversions.

Sp.G stands for Specific Gravity, or the ratio of the weight of a volume of liquid when compared to the weight of a similar volume of water. Water is said to have a Sp.G of 1.0 whereas most aviation fuels and oils have a Sp.G in the region of 0.72 to 0.82. Since 1ltr of water weighs 1kg and 1Imp gal weighs just over 10lbs it is possible to calculate the weight of a volume of liquid provided its Sp.G is known. The CRP computers are arranged to solve such problems with just one alignment of the circular slide rule scales and use of the cursor.

**Example:** Convert 708 Imp gal of fuel (Sp.G 0.74) into US gal, ltr, kgs and lbs.

*Rough Check:* 700 Imp gal x 1.2 = 840 Us gal = 3150 ltr  
x Sp.G r 0.75 = 2400 kg x 2.2 = 5280 lbs

### SET SLIDE RULE

Align 708 on the inner scale with the red **Imp gal** datum on the outer scale. Using the cursor as for volume conversions read off from their datums 850 US gal and 3215ltr. Now put the cursor through 0.74 on the **Sp.G** scale to the left of the ltrs datum (use the 74 below the **Sp.G** scale) and read off 2380kgs on the inner scale. Reposition the cursor through the 0.74 on the other Sp.G and read off 5250lbs on the inner scale.

Using these scale, if Sp.G and weight are known then volumes can be found and if a weight and volume are known the Sp.G can be found.

## CONVERSION OF TEMPERATURES BETWEEN °F & °C

There is a straightforward conversion scale at the bottom of this side of the computer, just read from one scale to the other.

That concludes the section the conversions that are programmed into the computer. A return to the use of ratios in the solution of other aviation problems now follows.

---

## SPEED, DISTANCE & TIME PROBLEMS

---

Speed is distance travelled in 60 minutes and this can be expressed as the ratio.

$$\frac{\text{SPEED (Dist in 60 min)}}{\triangle 60 \text{ (min)}} = \frac{\text{DISTANCE}}{\text{TIME (min)}}$$

This can be set on the circular slide rule like any other ratio and provided two of the variables are of known value the other will be solved. In these problems 60 is the constant and it is highlighted by having a triangle around the 60 on the inner scale.

As a further reminder of which scale to use the inner scale has **minutes** printed in red between 30 and 35.

## TO CALCULATE TIME

**Example:** How many minutes will it take an aircraft to fly 124 nm if its Ground Speed (GS) is 178 kt.

*Rough Check:* 120 nm at 180 kt =  $\frac{2}{3}$  hour = 40 min.

### SET SLIDE RULE

Align the 60 index mark on the inner scale with the GS of 178 kt on the outer scale. Position the cursor through the distance of 124 nm on the outer scale and read off the time of 41.8 minutes on the inner scale.

## TO CALCULATE GROUND SPEED (GS)

**Example:** If an aircraft covers 138 nm over the ground in 68 min what is its GS?

*Rough Check:* 60 mins =  $\frac{60}{68}$  of 68 mins, therefore GS =  $\frac{60}{68}$  of 138 nm = 124 nm in 60 mins or 124 kt.

### SET SLIDE RULE

Align time of 68 mins on the inner scale with distance covered 138 nm on the outer scale. Opposite the 60 datum mark on the inner scale read off GS 122 kt on the outer scale.

## TO CALCULATE DISTANCE

**Example:** An aircraft has a GS of 354 kt.  
How many nm will it cover in 94 mins?

*Rough Check:* 94 mins is just over 1½ hour, therefore distance covered will be just over 1½ x GS, say 1½ x 360 = 540 nm.

### SET SLIDE RULE

Align the 60 datum mark on the inner scale with the GS of 354 kt on the outer scale. Position the cursor through the time of 94 min on the inner scale and read off the distance of 554 nm on the outer scale.

**Note:** If using speed in mph then distances will be in stat.m and if using speed in kph then distances will be in km.

## FUEL CONSUMPTION, FUEL & TIME

Problems involving fuel are solved in a similar way to the Speed, Distance and Time problems. For fuel problems the ratio is:

$$\frac{\text{FUEL CONSUMPTION (or flow)}}{\triangle_{60}(\text{min})} = \frac{\text{FUEL (available or used)}}{\text{TIME (min)}}$$

Fuel quantities can be quoted in any of the volume or weight units already described in the conversion section. Take care not to mix units within a calculation.



## FUEL CONSUMPTION

**Example:** If 5450 kgs of fuel is consumed in 73 mins.  
What is the fuel consumption in kgs/hr?

*Rough Check:* 60 min =  $\frac{2}{3}$  of 73 mins, therefore fuel consumption =  $\frac{2}{3} \times 5500 = 4400$  kgs/hr.

### SET SLIDE RULE

Align the time of 73 min on the inner scale with the fuel consumed of 5450 kgs on the outer scale. Opposite the 60 datum mark of the inner scale read off the fuel consumption of 4480 kgs/hr on the outer scale.

## FUEL

**Example:** If fuel consumption is 16.9 Imp gal/hr how many Imp gal will be used in 17 min?

*Rough Check:* 17 min is just over  $\frac{1}{4}$  hr, therefore fuel used will =  $\frac{1}{4} \times 16 = 4$  Imp gal.

### SET SLIDE RULE

Align the 60 datum mark on the inner scale with the fuel consumption of 16.9 Imp gal/hr on the outer scale. Position the cursor through time 17 min on the inner scale and read off fuel used 4.8 Imp gal on the outer scale.

## TIME

**Example:** Fuel consumption is 510 US gal/hour and total fuel available is 3260 US gal. Calculate the endurance of the aircraft in minutes.

*Rough Check:*  $3000 \div 500 = 6$  hours or 360 min.

### **SET SLIDE RULE**

Align 60 datum mark on inner scale with the fuel consumption of 510 US gal/hr on the outer scale. Position the cursor through the fuel available of 3260 US Gal on the outer scale and read off the endurance of 384 min on the inner scale.

---

## **CALCULATION OF TRUE AIRSPEED (TAS)**

---

The Airspeed Indicator (ASI) measures the difference between Pitot and Static pressures, this difference being the dynamic pressure due to the forward motion of the aircraft. Dynamic pressure is generated by the number of air molecules that collide with the airframe as it moves forward and is therefore a function of both air density and TAS.

The ASI is calibrated to indicate speed on the assumption that air density has a fixed value of 1225 grammes/cubic metre (msl International Standard Atmosphere density). Since actual air density varies with altitude and temperature a correction, called density error correction, is necessary if TAS is to be calculated.

The Indicated Airspeed (IAS) showing on the ASI has first to be corrected for any instrument and position errors, the correction normally being found on a calibration card placed near the ASI. The corrected speed is known as the Rectified Airspeed (RAS) or now more usually Calibrated Air Speed (CAS) and is used in conjunction with pressure altitude and corrected outside air temperature (COAT)(often referred to as Static Air Temperature - SAT) to solve for TAS on the computer.

## CALCULATION OF RAS/CAS TO TAS (UP TO 300 KT)

Rotate the inner disc of the computer to align the COAT on the outer edge of the **Air Speed** window with the pressure altitude (altitude with 1013 mb set on the altimeter sub-scale) inside the window. Position the cursor through the RAS on the inner circular slide rule scale and read off TAS on the outer scale.

**Example:**            **Pressure altitude 18000 ft, COAT -30°C,  
RAS 170 kt. What is TAS?**

*In **Air Speed** window set 18 (pressure altitude x 1000ft) opposite -30°C on the COAT scale. Position the cursor through the **RAS** of 170kt on the inner slide rule scale and read off the **TAS** of 220 kt on the outer scale.*

**Note:** *As a reminder of which way to read RAS to TAS there is a red RAS on the inner scale, between 35 and 40, and a red TAS on the outer scale, also between 35 and 40.*

At high TAS air becomes compressed and causes an extra pressure over and above normal Pitot pressure to be sensed by the ASI. This compressibility results in the TAS found on the computer coming out at a higher value than the correct TAS. In the ASI a modification to the calibration formula eliminates this error at the calibration density of 1225gm/cub metre, but this correction does not hold good above a TAS of 300 kt as the density decreases. The higher and faster (in excess of a TAS of 300kt) the aircraft flies the larger the uncorrected compressibility error becomes. Any time the conversion of RAS to TAS results in a TAS of over 300 kt a subtractive correction has to be made using the **Comp. Corr** (compressibility correction) window on the computer.

## CALCULATION OF RAS TO TAS (Over 300 kt)

Having calculated RAS to TAS, as previously described, if the TAS comes out at over 300 kt proceed as follows. Note the value of this initial TAS and apply it in the formula to be found by the **Comp. Corr** window, ie  $TAS/100 -3$  Div. The answer this gives is the number of divisions that the arrow pointing at the **Comp.Corr.** window has to be moved to the left against the scale visible in the window. This scale varies and has large spacing at high altitude and very close spacing at low altitudes; in fact at msl it is at infinity  $\alpha$ . Moving the pointer to the left will reposition the RAS opposite a lower value TAS which is the correct TAS to use.

**Example:** Pressure altitude 35000 ft, COAT  $-47^{\circ}\text{C}$ , RAS 280 kt, what is the TAS?

In **Air Speed** window set 35 (pressure altitude x 1000ft) opposite  $-47^{\circ}\text{C}$  on the COAT scale. Position the cursor through the RAS of 280 kt on the inner slide rule scale and read off the initial TAS of 500 kt on the outer scale. Since this is over 300 kt enter the 500 kt initial TAS into the formula giving  $500/100 -3 = 2$  Div. The arrow is pointing just to the left of 38 on the scale in the **Comp. Corr** window (numbers increase to left on this scale) so move the inner disc to position the arrow 2 divisions to the left, just beyond 40. Reposition the cursor through the RAS of 280 kt on the inner scale and read off the correct TAS of 480 kt on the outer scale.

**Note:** The expression *Equivalent Airspeed (EAS)* may be encountered from time to time; this is RAS corrected for compressibility error only. EAS is used in design work and test flying; it is not normally used in every day flying.

## CALCULATION OF TAS FROM MACH NUMBER

$$\text{MACH Number} = \frac{\text{TAS}}{\text{Local Speed of Sound}}$$

Since local speed of sound is temperature dependent, temperature is the only variable needed to programme the computer. If 10 on the inner scale of the circular slide rule is aligned with any number between 575 and 675 on the outer scale an arrow labelled **Mach No. Index** will appear in the **Air Speed** window. Aligning this arrow with the COAT scale on the outside of the **Air Speed** window positions the two circular slide rule scales so that TAS in kts is now on the outer scale, opposite Mach number on the inner scale. It follows that the TAS in kts opposite M 1.0 must also be the local speed of sound in kts. Whenever the **Mach No. Index** arrow is visible in the **Air Speed** window the **Comp.Corr.** window will be found to be blank, this is because compressibility errors are already corrected for in the Machmeter mechanism and no correction is necessary on the computer.

**Example:**      **Temperature -45°C , Mach No 0.82**  
**What is the TAS and the local speed**  
**of sound?**

In **Air Speed** window align **Mach No. Index** arrow with COAT -45°C on the temperature scale. Position cursor through M 0.82 on the inner slide rule scale and read off TAS 482 kt on the outer scale, reposition cursor through M 1.0 and read off local speed of sound 588 kt.

---

# TEMPERATURE RISE SCALE

---

This scale is for use by pilots who prefer to use the temperature shown on the indicated temperature gauge in the aircraft rather than the meteorological forecast temperatures. Except at very low speeds the indicated temperature is always higher than COAT due to kinetic heating on the temperature probe. Kinetic heating is a function of TAS and the scale gives the amount of over indication of temperature at different TAS's. The value found should be subtracted from indicated temperature to give COAT. The method is to compute for RAS to TAS using indicated temperature to get an approximate TAS, use this TAS to find the temperature to get an approximate TAS, use this TAS to find the temperature rise on the scale and use this to amend the indicated temperature to compute COAT. Finally recompute RAS to TAS using the newly computed COAT to get the correct TAS.

**Example:**      **Indicated temperature -30°C,**  
                         **pressure altitude 25000 ft, RAS 200 kts.**  
                         **What is TAS?**

In **Air Speed** window align 25 (pressure altitude x 1000 feet) with indicated temperatures -30°C on the COAT scale. Position cursor through RAS of 200 kts on the inner circular slide rule scale and read off approximate TAS of 297 kts on the outer scale. Enter **Temp Rise** scale with this TAS and pick off temperature rise of 9°C and subtract it from the indicated temperature, -30°C -9°C=COAT -39°C. Recomputing RAS to TAS using -39°C will give a correct TAS of 292 kts.

**Note:** *If your first (approximate) TAS comes to more than 300 kts, compressibility correction must be applied, even on the first rough TAS to find the Temperature Rise. It must then be applied again in the accurate TAS, if above 300 knots.*

---

## MINUTES TO HOURS & MINUTES SCALE

---

This is the circular yellow scale labelled **hours** in red, that lies within the inner circular slide rule scale. It gives straight conversion between minutes on the inner slide rule scale and hours and minutes on the hours scale.

**Example:** Convert 274 minutes to hours & minutes.

Align cursor through 274 minutes on the inner slide rule scale and read off 4.30 on the hours scale opposite 270 minutes, add 4 minutes to this value giving 4 hours 34 minutes.

---

## CALCULATION OF TRUE ALTITUDE

---

This is retained for its instructional value only. If you do not need to understand the cause and effect of temperature error on the Altimeter give this section a miss.

To give a datum, Altimeters are calibrated to what is known as the International Standard Atmosphere (ISA). This *assumes*, amongst other things, a particular temperature structure of the atmosphere. You can see this assumed structure by lining up the two scales of the circular slide rule and then looking at the **Altitude** window. Try it. Set 10 on the inner slide rule scale opposite 10 on the outer scale (all the other numbers will be matched with their counterparts as well), against the altitudes on the edge of the **Altitude** window read off the ISA temperature.

**Example:** At 0 feet (msl) the ISA temperature is +15°C and at 20,000 feet it is -25°C.

**Note:** *The altitudes on the Altitude window are labelled Pressure Altitude, that is to say altitude measured from the standard pressure datum of 1013 millibars.*

The inner slide rule scale now represents the Indicated Altitude measured from the local QNH (mean sea level pressure) setting and the outer slide rule scale now gives the corresponding True Altitude. It follows that if the ambient temperature structure is identical to the ISA then the True Altitude will be the same as the Indicated Altitude. The setting put on as an example illustrates this situation.

However if the temperature at 20,000 feet were colder than the ISA temperature, say -35°C, lining up 20,000 feet Pressure Altitude opposite -35°C in the **Altitude** window will move the inner slide rule scale anti-clockwise and now opposite 20,000 feet Indicated Altitude on the inner scale (Assuming QNH = 1013 millibars) on the outer scale the True Altitude is seen to be 19,200 feet. Similarly a warmer than ISA temperature of -10°C at 20,000 feet will give a True Altitude of 21200 feet for an Indicated Altitude of 20,000 feet.

In these examples the Altimeter is sensing the same pressure and giving the same Indicated Altitude. In the colder than ISA situation the True Altitude is lower than Indicated Altitude and in the warmer than ISA situation it is higher than Indicated Altitude. The cause of this is the temperature effect on air density. In the colder air the density increases as the air contracts and packs more weight of air into a given volume, whereas warmer air becomes less dense as it expands. In the colder, more dense, air the rate of fall of pressure with altitude is faster than in the ISA and in the warmer, less dense, air the rate of fall of pressure with altitude is slower.



It follows that if an aircraft is flying from a warm air mass into a cold air mass at a constant Indicated Altitude the True Altitude will be decreasing due to the temperature change.

---

## CALCULATION OF DENSITY ALTITUDE

---

The density of the air directly affects the performance of any aircraft. A reduction in air density results in lower engine power, longer take-off and landing runs and slower rates of climb. In the case of an engine failure on a multi-engined aircraft the air density has a bearing on rate of drift down and the final altitude at which level flight can be maintained.

To give a datum, some performance graphs and charts are based on the assumption that the aircraft is flying in ISA conditions and it becomes necessary to convert the prevailing conditions into the equivalent ISA conditions to enable these graphs and charts to be used.

**Density Altitude** is the altitude in the ISA at which the prevailing density would be found. If the temperature at an airfield is higher than the ISA temperature for the airfield elevation then the air density will be lower in value and the Density Altitude (equivalent ISA Altitude) will be higher than the airfield elevation. Most, but not all, fixed wing performance graphs have a net in the graph that performs this conversion when entered with temperature and airfield elevation. For operators whose graphs or tables do not incorporate such a refinement the CRP-5 computers have a **Density Altitude** window. This is a 'read-out' window only, the airfield elevation and temperature being first entered into the **Air Speed** window.

Rotate the inner disc of the computer to align the airfield elevation (using the Press Alt x 1000 ft scale) inside the **Air Speed** window with the airfield surface temperature (using the COAT outer scale of the **Air Speed** window). Go the **Density Altitude** window and opposite the arrow read of the **Density Altitude** inside the window.

**Example:**      **Airfield elevation 5000 feet amsl,  
surface temperature +5°C.  
What is the Density Altitude?**

Set 5000 feet in the **Air Speed** window opposite +5°C (just to the left of 0) on the COAT scale. Opposite the arrow on the Density Altitude window read off the **Density Altitude** of 5000 feet. In this case airfield elevation and **Density Altitude** are the same because +5°C happens to be the temperature at 5000 feet in the ISA.

Now try the same airfield on a really hot day with the surface temperature of +30°C. What is the **Density Altitude** now?

Set 5000 feet in the **Air Speed** window opposite + 30°C (remember + is to the left of 0) on the COAT scale. Opposite the arrow on the **Density Altitude** window read off the **Density Altitude** of 8000 feet.

Remember the hotter and higher the airfield, the poorer the aircraft will perform, and some payload may have to be shed to ensure safe operation of the aircraft.

---

## **SIDE 2: The Triangle of Velocities Computer**

---

### **CRP-5 & 5W COMPUTER**

The only difference between these two computers is the wind arm on the 5W model. How to use this wind arm, which does away with the need for a pencil to mark in the wind cross, is explained later.

---

### **DRIFT/VARIATION & TRUE HEADING INDEX**

---

This fixed scale extends 50°C either side of the central index mark, (labelled TRUE HEADING), at the top of the computer (See inside rear cover). The scale can be used for either application of drift from heading to track or for applying variation to convert °(T) to °(M) or vice versa.

#### **APPLICATION OF DRIFT**

Drift is the angle between Heading and Track and is always applied FROM Heading To Track. The terms Port (left) and Starboard (right) drift indicate which side of heading the Track lies. Aligning Heading on the window disc with the index mark on the fixed scale, reading from the drift scale into the window disc will give the Track.

**Example:**        **Heading 075° (T), drift 11° Port.**  
                      **What is the Track °(T)?**

*Align.* Heading 075°(T), on the window disc with the index mark. Reading from 11° Port drift on the fixed scale find Track 064° (T) on the window disc.

**Example:**      **Heading  $227^{\circ}$  (T), results in a Track of  $241^{\circ}$  (T). What is the Drift?**

*Align.* Heading  $227^{\circ}$ (T), on the window disc with the index mark. Reading from Track  $241^{\circ}$ (T) on the window disc find drift of  $14^{\circ}$  Starboard on the fixed scale.

## APPLICATION OF VARIATION

Aligning a known Heading  $^{\circ}$ (T) with the index mark enables the Heading  $^{\circ}$ (M) to be read off the window disc opposite the local variation of the fixed scale. Similarly if Heading  $^{\circ}$ (M) is aligned with the local variation then Heading  $^{\circ}$ (T) will be found under the index mark.

**Example:**      **Heading  $217^{\circ}$  (T), variation  $21^{\circ}$  East. What is the Heading  $^{\circ}$ (M)?**

*Align.* Heading  $217^{\circ}$ (T), on the window disc with the index mark. Reading from  $21^{\circ}$ East on the fixed variation scale find Heading  $196^{\circ}$ (M) on the window disc.

**Example:**      **Heading  $005^{\circ}$  (M), variation  $8^{\circ}$  West. What is the Heading  $^{\circ}$ (T)?**

*Align.* Heading  $005^{\circ}$ (M), with  $8^{\circ}$ West on the fixed variation scale. Read of Heading  $357^{\circ}$ (T) on the window disc opposite the index mark.

---

## THE SLIDE

---

This has two sides, a low speed side (marked **L** at the top right) with speed arcs from 40 to 300 and a high speed side (marked **H** at the top right) with speed arcs from 150 to 1050. The L side has a squared section at the bottom which is used to calculate head and cross wind components on runways.

As mentioned in the introduction, these slides have graduated sides for measuring in inches and millimetres or for measuring nautical miles on charts of 1:250,000 or 1:500,000 scales.

Both sides have drift lines. Below the 100 speed arc on the **L** side and below the 300 speed arc on the **H** side the lines are every  $2^\circ$  of drift. At the higher speeds the lines are every  $1^\circ$  of drift. When carrying out calculations care must be taken not to read  $2^\circ$  drift lines at  $1^\circ$  lines and vice versa.

---

## THE TRIANGLE OF VELOCITIES

---

*In flight an aircraft is subjected to three velocities:*

1. Movement of the aircraft relative to the air. The components of this velocity are aircraft **Heading (Hdg)** and **TAS**.
2. Movement of the air relative to the ground. The components of the **Wind Velocity (WV)** are Wind Direction and Wind Speed.
3. Movement of the aircraft relative to the ground. The components of this velocity are aircraft **Track (Trk)** and **GS**.

**Note:** *The direction of **hdg** and **trk** is that towards which the movement is being made, whereas the direction of the **wind** is always that from which the wind is blowing.*

*In navigation the main problems regarding these velocities are:*

1. Solving for Trk and GS when Hdg and TAS plus WV are known.
2. Solving for WV when Hdg and TAS plus Trk and GS are known.
3. Solving for Hdg to steer and expected GS when TAS, WV and desired Trk are known.

These problems are most easily solved by drawing a triangle of velocities to a common vector scale and direction datum. The rotatable window and slide enable the triangle to be solved with a minimum of drawing. In the examples that follow speeds will be given in kts and directions in °(T). The methods are those employed in commercial aviation and, as will be seen, the way the various components are set up is identical in every case.

### **TO SET ON A WIND VELOCITY (WV)**

Align wind direction on the window disc with the index mark on the fixed scale and, using a soft pencil, mark a cross on the centre line **BELOW** the centre dot at a distance from the centre dot equal to the wind speed. Use the spacing on the slide to find the cross position.

**Example:**      **Set WV 210°/30 on the window disc using the low speed L side of the slide.**

Align wind direction 210° on the window disc with the index mark on the fixed scale. Move the **L** slide to position, say, the 130 speed arc through the centre dot and mark a cross **BELOW** the centre dot where the 100 speed arc crosses the centre line.

This cross now marks the end of the vector of a WV blowing from  $210^\circ$  at a speed of 30 kts; note also that it is blowing out from the centre dot. If the slide is now turned over to the high speed **H** side of the slide it will be seen that what had been a 30kts wind speed on the **L** side has become an 80 kts wind speed on the **H** side. This is because the scales are different and it means any time the slide is switched from **L** to **H** or vice versa, the WV must be redrawn on the window.

## **SOLVING FOR TRACK (TRK) GROUND SPEED (GS) KNOWING HDG & TAS PLUS WV**

Since the highest GS possible is TAS plus wind speed (a tail wind) and the lowest GS possible is TAS minus wind speed (a head wind) select the side of the slide, **L** or **H**, which will accommodate the range of possible GS's and slide it into position with the name **POOLEYS** at the top.

Mark on the WV cross for the known WV (see previous section).

Move the slide up or down to position the speed arc equal to TAS through the centre dot.

Align the Hdg direction on the window disc with the index mark on the fixed scale.

### **The computer is now set up, no further movements are required.**

Read off the amount of drift from the drift line which lies under the wind cross. Remember, to the left of the centre line is Port drift and to the right of the centre line is Starboard drift (reminders of this are on the fixed scale). On the fixed scale locate the amount of drift just found and read from it into the window disc to find Trk direction. Read off the GS from the speed arc which lies under the wind cross.

**Example:** Hdg.  $116^{\circ}(T)$ ; TAS 120kts and WV  $260^{\circ}(T)$ /40 kts. Find Trk $^{\circ}(T)$  and GS kts.

Maximum GS =  $120 + 40 = 160$  kts, minimum GS =  $120 - 40 = 80$  kts, therefore use **L** side of slide.

Mark on the wind cross, with  $260^{\circ}$  under the index mark pencil cross 40 speed units **BELOW** the centre dot. Move the slide to position the 120 (TAS) speed arc through the centre dot. Rotate window disc to align Hdg  $116^{\circ}(T)$  under the index mark.

**The computer is now set up with TAS under the centre dot, Hdg aligned with the index mark and WV blowing out from the centre dot.**

Under the wind cross read off drift  $9^{\circ}$  Port and GS 154 kts. From  $9^{\circ}$  Port on the fixed scale read in to find Trk  $107^{\circ}(T)$  on the window disc.

**Answer:** Trk  $107^{\circ}(T)$  GS 154 kts

## SOLVING FOR WIND VELOCITY (WV)

Knowing Hdg and TAS plus Trk and GS.

Select the side of slide (**L** or **H**) that will accommodate both TAS and GS. Move the slide to position the TAS speed arc through the centre dot. Align the Hdg direction on the window disc with the index mark on the fixed scale.

**The computer is now set up ready for marking on the wind cross to find the WV.**

Read from Trk direction on the window disc outwards to find drift on the fixed scale.



Locate the drift line of this value of drift on the slide and pencil the wind cross on the window where this line crosses the GS speed arc.

Rotate the window disc to position the wind cross on the centre line **BELOW** the centre dot.

The direction now aligned with the index mark is the wind direction and the length of the vector from the centre dot to the wind cross is the wind speed.

**Example:** Hdg 227°(T); TAS 420 kts; Trk 234°(T);  
GS 385 kts. What is the WV?

With TAS 420 kts and GS 385 kts use the H slide. Move the slide to position the 420 (TAS) speed arc through the centre dot. Align the Hdg of 227°(T) on the window disc with the index mark on the fixed scale.

**The computer is now set up with the TAS under the centre dot and Hdg aligned with the Index mark, ready for marking on the wind cross to find WV,**

Read from Trk 234°(T) on the window disc outwards to find that drift is 7° Starboard, the wind cross must therefore lie on the 7° Starboard drift line on the slide. With a pencil mark the wind cross on the window at the point where the 7° Starboard (right) drift line cuts the 385 (GS) speed arc on the slide.

Rotate the window disc to position the wind cross over the centre line **BELOW** the centre dot.

Under the index mark read off the wind direction 177°(T) and from centre dot to wind cross read off wind speed 60 kts.

**Answer:** WV 177°(T)/60 kts.

**Note:** *If an aircraft has doppler or inertial equipment fitted the present drift and GS can be read off the indicator and used with Hdg and TAS to find a spot WV using the method just described.*

## **SOLVING FROM HEADING (HDG) & GROUND SPEED (GS) KNOWING WV, TAS AND REQUIRED TRK**

Check for maximum and minimum possible GS and select the appropriate side of the speed slide (**L** or **H**) to use.

Mark on the WV as previously described, putting the wind cross **BELOW** the centre dot.

Move the slide to position the TAS speed arc through the centre dot.

To set about finding the Hdg to steer first align the desired Trk direction on the window disc with the index mark on the fixed scale (treating the index as zero drift) and read off the drift from the drift line passing through the wind cross.

If the drift so found is zero (matching the zero drift opposite the Trk direction) then the Hdg to steer will be the same as the required Trk direction and all that has to be done to complete the solution is to read off the GS from the speed arc passing through the wind cross.

It is more likely that the wind cross will be off to one side of the centre line, lying over one of the angled drift line on the slide. If so, read off this value of drift and rotate the window disc to align the required Trk direction with the identical value of drift on the fixed scale. In so doing the wind cross may shift its position to lie over a different drift line, in which case reposition the required Trk direction to lie under this new value of drift on the fixed scale. Keep adjusting the position of the required Trk direction until the drift opposite it on the fixed scale is the same as the drift line under the wind cross. In practice this adjustment only takes seconds to do.

### **The computer is now set up ready for reading off Hdg & GS.**

Read off Hdg to steer on the window disc opposite the index mark on the fixed scale. Read off GS from the speed arc passing through the wind cross.

**Note:** In all three triangle of velocity problems described the computer is set up when:

- (a) TAS lies under the centre dot.
- (b) Hdg is opposite the index mark.
- (c) The wind cross is at the point of intersection of the GS speed arc and the drift line.
- (d) Trk is opposite this same drift value on the fixed scale.

*Before giving an example of the last type of problem.*

## A WORD OF WARNING FOR CPL/ATPL STUDENTS

*An alternative way of solving this problem has its advocates who claim that their method is easier because it does not require any moving of the computer to balance the drifts. Unfortunately their method requires the WV to be marked on the window in reverse and the learning of a completely new set of rules. Furthermore, unlike the professionals' method described above, their method cannot be used to solve all other types of problems. The CPL/ATPL student is strongly advised to stick with the methods in this handbook and avoid getting involved with limited use short-cuts, particularly if they require committing non-standard procedures to memory.*

### – END OF WARNING –

**Example:** TAS 170 kts; WV 083°(T)/35 kts; required Trk 036°(T). What is the Hdg °(T) to steer and what GS will it give?

Maximum GS  $170 + 35 = 205$  kts, minimum GS  $170 - 35 = 135$  kts, therefore use L side of slide. Mark on the wind cross, with  $083^\circ$  under the index mark pencil a cross 35 speed units **BELOW** the centre dot. Move the slide to position the 170 (TAS) speed arc through the centre dot. Rotate the window disc to align required Trk  $036^\circ$  (T) with the index mark (zero drift). Under the wind cross now read off  $10^\circ$  Port drift mark on the fixed scale. Recheck drift under the wind cross; it is still  $9^\circ$  Port so the drifts balance.

The computer is now set up with TAS under the centre dot, the wind vector blowing from the centre dot with its wind cross over the intersection of drift line and GS speed arc, the required Trk opposite the same value of drift on the fixed scale and the Hdg to steer under the index mark.

Read off Hdg to steer  $045^\circ$ (T) under the index mark and the GS 144 kts on the speed arc through the wind cross.

**Answer:** Hdg to steer  $045^\circ$ (T) and GS 144 kts.

---

## TO CHECK WV AT A TURNING POINT

---

Various means of finding drift exist and if by any of these methods drift is checked when inbound to, and outbound from, a turning point it is possible to check the WV, provided the change of heading is large. Inbound Hdg and drift, Outbound Hdg and drift plus TAS are the only requirements to solve for WV.

Set speed arc of TAS through centre dot. With Inbound Hdg aligned with the index mark draw a pencil line on the window down the Inbound drift line on the scale. Rotate the window disc to align the Outbound Hdg with the index mark and draw a pencil line on the window down

the Outbound drift line to cut the first pencil line. Where the two lines intersect is the wind cross. Rotate the window disc to position the wind cross on the centre line **BELOW** the centre dot. Read off wind direction under the index mark. Read off the length of the vector from the centre dot to the wind cross to find the wind speed.

**Example:** TAS 220 kts; Inbound Hdg 195°(T); Inbound drift 6° Starboard; Outbound Hdg 278°(T); Outbound drift 4° Port.

Using the **L** side of the slide position the 200 (TAS) speed arc through the centre dot. Align the Inbound Hdg 195°(T) with the index mark. Draw a pencil line on the window down the 6° Starboard drift line (Inbound drift). Rotate the window disc to align the Outbound Hdg 278°(T) with the index mark. Draw a pencil line on the window down the 4° Port drift line (Outbound drift) to cut the first pencil lines at what is now the wind cross. Rotate the window disc to position the wind cross on the centre line **BELOW** the centre cross. Read off wind direction 066°(T) under the index mark. Read the vector length from the centre dot to the wind cross giving a wind speed of 32 kts.

**Answer:** WV 066°(T)/32 kts.

**Note:** *This check is only valid if the two drift lines cross each other at an angle of from 70° to 90°.*

---

## TO FIND HEAD & CROSS WIND COMPONENTS ON A RUNWAY

---

These components are solved on the squared section at the bottom of the **L** side of the slide. The scale of this squared section is the same vertically and horizontally.

Move the slide to position the top line of the squared section through the centre dot. Rotate the window disc to align the surface wind direction with the index mark. Pencil in the wind cross on the centre line **BELOW** the centre dot using the squared scale. Rotate the window disc to align the runway direction with the index mark. The scale measured vertically from the top line to the wind cross gives the head wind component and the scale measured horizontally **FROM** the centre line **TO** the wind cross gives the cross wind component and its direction of movement.

**Example:** Calculate the head and cross wind components on RW19 if the ATC surface WV is 150/25.

**Note:** RW directions are to the nearest  $10^\circ(M)$  and ATC surface WV is always given in  $^\circ(M)$ . They do not need converting into  $^\circ(T)$  to solve for the wind components on the RW.

**Note:** TAF and METAR WV are in True; ATC and ATIS WV are magnetic.

Position the top line of the squared section through the centre dot. Align wind direction  $150^\circ(M)$  with the index mark and pencil in the wind cross on the centre line 25 units **BELOW** the centre dot using the squared scale. Rotate the window disc to align  $190^\circ(M)$  (RW19) with the index mark, this will displace the wind cross to the right of the centre line. Read off the head wind component of 20 kts vertically down from the top line to the wind cross. Read off the cross wind component of 17 kts horizontally **FROM** the centre line **TO** the wind cross, i.e., from Port (left) to Starboard (right).

**Answer:** Head wind component 20 kts, cross wind component 17 kts from left to right.

**Note:** *If having set on the surface WV and a RW direction the wind cross position is above the top line the RW in question would have a tail wind, try the reciprocal of the RW to get a head wind component. The best RW to use is the one nearest into the surface WV as this will have the best head wind and least cross wind. Take-off or landing should NEVER be attempted on any RW giving a crosswind component greater than the maximum crosswind limitation for the aircraft type being flown.*

---

## CRP-5W-WIND BAR

---

This computer has a rotatable transparent wind bar pivoted on the centre dot of the window disc. This bar has a **L** scale on one arm and an **H** scale on the other arm, for use with the **L** and **H** speed slides respectively. So as not to obscure too much of the slide the scale number are abbreviated, the **L** scale marks of 1, 2, 3, 4, 5 and 6 representing 10, 20, 30, 40, 50 and 60 kts and the **H** scale marks of 5, 10 and 15 representing 50, 100 and 150 kts.

### TO SET ON A WIND VELOCITY (WV)

First decide which side of the speed slide is to be used and slide it into position behind the window. Next, using the arm with the scale that does not match the slide scale, align the centre of the bar with the wind direction on the outside of the window disc. Finally locate the wind speed on the arm with the scale that matches the slide scale. The bar and window are now rotated as one and the point under the wind speed is used as if it were the wind cross.

**Example:**      **Set the wind bar for a WV of 045°(T)/30 kts  
for use with a TAS of 170 kts.**

Maximum possible GS  $170+30=200$  kts, minimum possible GS  $170-30=140$  kts, therefore use the **L** slide and the **L** scale on the wind bar. Insert the **L** slide behind the window and rotate the wind bar to align the arm with the non-matching scale (H in this case) with the wind direction of  $045^\circ$ (T) on the window disc. On the **L** bar of the wind arm locate the 3 (30 kts) mark and use this mark as if it were a wind cross.

**Note:** *If at first you are not sure that you are setting the bar correctly rotate the window disc to align wind direction with the index mark. Rotate the wind bar to the vertical, positioning the matching scale arm to BELOW the centre dot, then locate the speed on the matching scale arm.*

## **SOLVING FOR WIND VELOCITY (WV) KNOWING HDG AND TAS PLUS TRK & GS**

Proceed exactly as for the CRP-5 except that instead of marking the wind cross at the intersection of the drift and GS, the arm of the wind bar whose scale matches the slide scale, is rotated to pass through the point of intersection. Read off the wind direction on the window disc opposite the other arm of the wind bar and read off wind speed on the matching scale arm at the point of intersection of the drift and GS.

Try reworking the example given for the CRP-5 by this method.

---



---

# NOTES

---

---

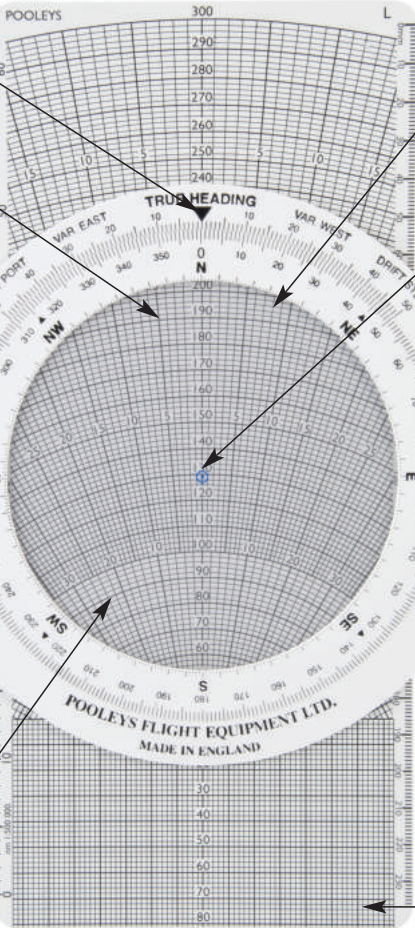
# NOTES

---

Index Mark

Draft Lines

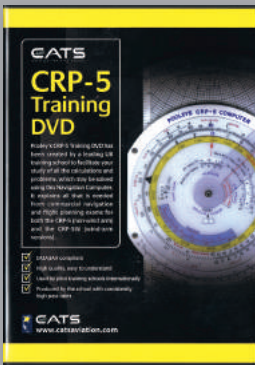
Speed Arcs



Rotating Window

Centre Dot

Slide



Pooleys CRP-5 Training DVD has been created by a leading UK training school to facilitate your study of all the calculations and problems, which may be solved using this Navigation Computer.



**Pooleys Flight Equipment  
Elstree Aerodrome  
Hertfordshire WD6 3AW  
United Kingdom**

Tel: +44(0)20 8207 3749

Fax: +44(0)20 8953 2512

Email: [sales@pooleys.com](mailto:sales@pooleys.com)

Website: [www.pooleys.com](http://www.pooleys.com)