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DOCUMENT TITLE

CPL NAVIGATION 2 (AUSTRALIA)

CHAPTER 10 – 1 IN 60 RULE HEADING CHANGES

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1 IN 60 RULE HEADING CHANGES

10.1 Introduction

Pilots sometimes find themselves making quick calculations in order to navigate, while still executing other tasks in the aircraft.

The answers obtained with these types of calculations are approximations and are referred to as "mental DR" (Dead, or Deduced Reckoning) methods. It is also normal procedure to apply accurate calculations using other techniques (i.e. plotting etc.) as to double check the answers obtained with the "mental" methods.

A method often used in practical navigation, is the "1-in-60 Rule".

Only the core concept of the 1-in-60 Rule is revised below, followed by the additional content as per the Part 61 CPL Navigation syllabus. For detailed revision on the 1-in-60 Rule, refer to Navigation 1 Chapter 10.

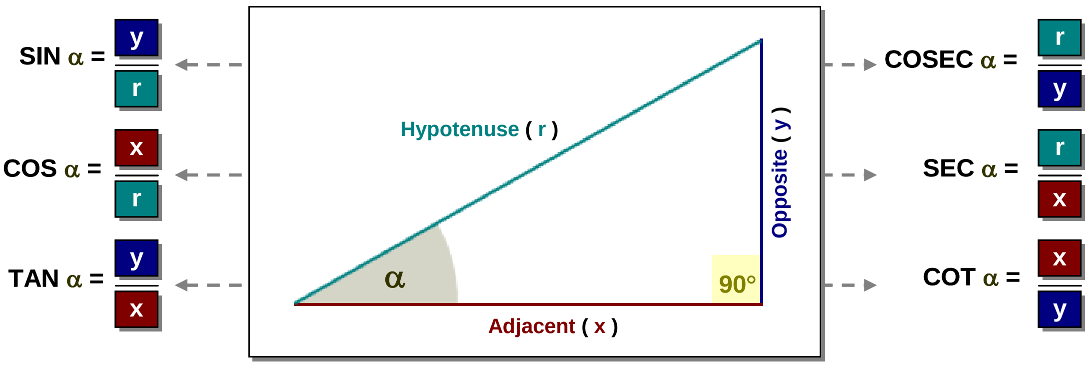
10.2 Basic 1-In-60 Rule Principle

In order to understand the 1-in-60 rule the three Trigonometric functions and its co-functions are important, the functions are:

Sine <----------> Cosecant

Cosine <----------> Secant

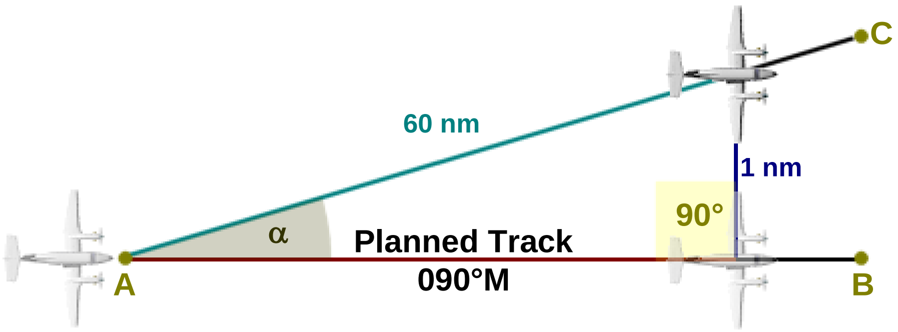
Tan <----------> Cotangent



Trigonometrical functions are used to determine certain angles.

Example: Flying from point **A** to point **B** the heading to steer is 090° magnetic.

After flying for 60 nm, it is discovered that we are flying towards point **C** and positioned 1 nm off the planned track.



Calculate the angle (**α**) by means of trigonometry.

In the right-angled triangle, to calculate angle (**α**) the distance of the opposite side (**1 nm**) and the hypotenuse (**60 nm**) is used.

With the opposite (**1 nm**) and the hypotenuse (**60 nm**), determine the SINE value of angle "**α**".

$$\text{Sin } \alpha = \frac{\text{Opposite (y)}}{\text{Hypotenuse (r)}}$$

$$\text{Sin } \alpha = \frac{1}{60}$$

$$\text{Sin } \alpha = 0.0167$$

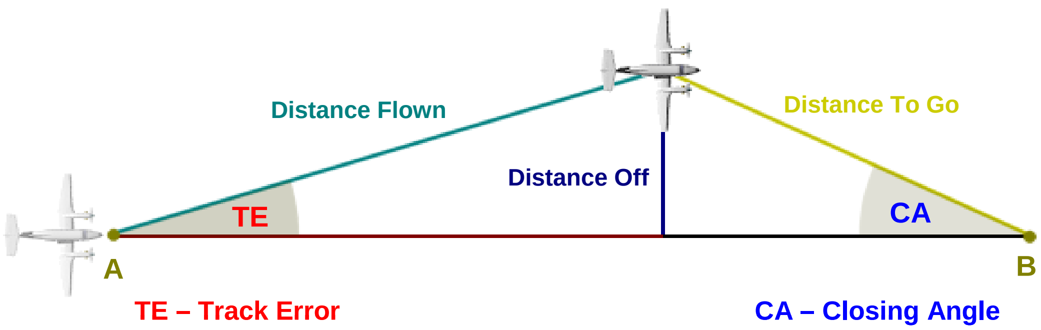
$$\alpha = \frac{0.0167}{\text{Sin}} \textit{ or } \text{Cosec } 0.0167$$

$$\alpha = 0.955^{\circ} \textit{ or } 0^{\circ}57'$$

If we round this off to 1°, we can say as a rule of thumb (for "Dead Reckoning" purposes), the following:

"If an aircraft is 1 nm off track in 60 nm flown, then the track error is 1°."

For navigation the angles and sides in the triangle will be referred as:



If the length of the **distance flown side** is 60 units, the length (using the same units) of **the distance off side** opposite the track error angle, will be approximately the same as the **number of degrees in the track error angle**.

The table below indicates the difference between the values of the track error angle calculated by means of trigonometry and the rounded values obtained by applying the 1-in60 Rule:

Short Side	Sine of Angle	Angle	Rounded Figure
1	1/60 = 0.0167	0°57'	1°
10	10/60 = 0.1667	9°36'	10°
20	20/60 = 0.3333	19°28'	20°
30	30/60 = 0.5000	30°00'	30°
35	35/60 = 0.5833	35°41'	35°
40	40/60 = 0.6667	41°49'	40°
45	45/60 = 0.7500	48°35'	45°

If the track error is less than 30°, the result will be accurate to about 0.5°.

If the track error is less than 40°, the result will be accurate to about 2°.

The 1-in-60 rule is a quick "DR" method of calculating an error, differences of up to 2° is acceptable.

10.3 The 1-In-60 Rule Formula

If an aircraft is 7 nm off track in 60 nm flown, according to the 1-in-60 rule, the track error is 7°.

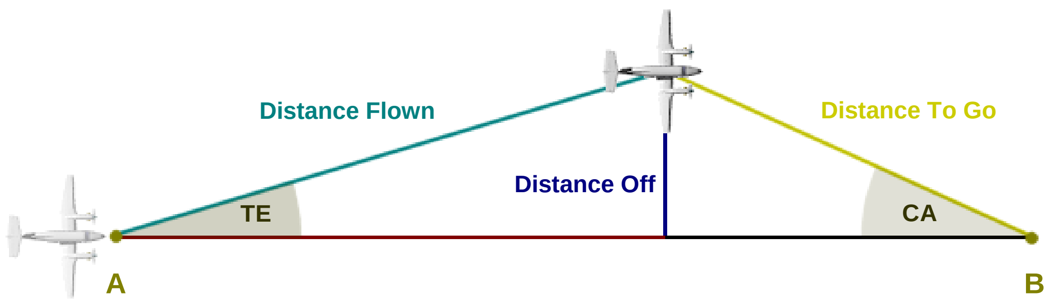
However, what if the distance flown is not equal to 60 nm?

To resolve the track error for distances flown, other than 60 nm, **we need to be able to apply** a formula that can be used on the circular slide rule of the Navigation Computer or the electronic calculator.

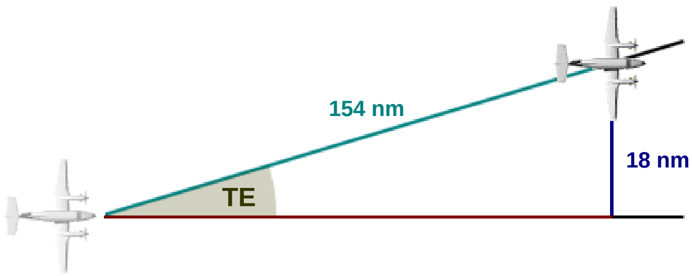
The formulae to apply are as follows:

$$\frac{\text{Track Error (TE)}}{60} = \frac{\text{Distance Off}}{\text{Distance Flown}}$$

$$\frac{\text{Closing Angle (CA)}}{60} = \frac{\text{Distance Off}}{\text{Distance To Go}}$$



<u>Example</u>: An aircraft is 18 nm left of track after having flown for 154 nm. What is the track error?



$$\frac{\text{Track Error (TE)}}{60} = \frac{\text{Distance Off}}{\text{Distance Flown}}$$

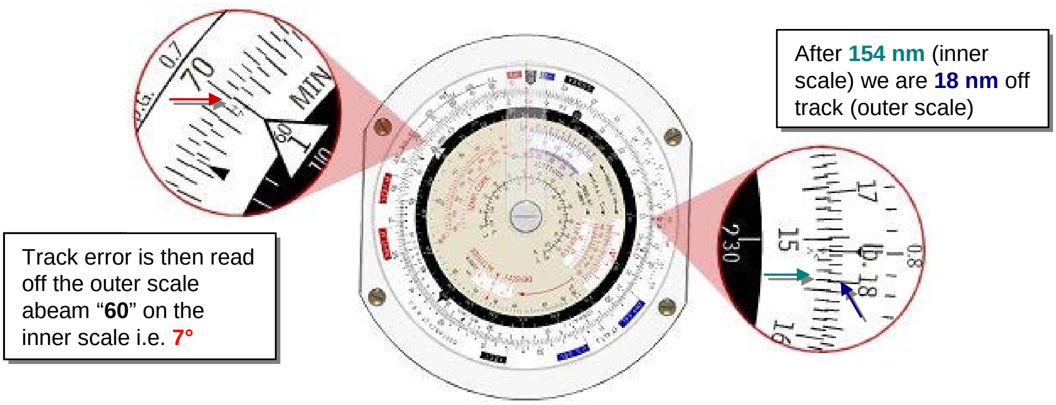
$$\frac{TE}{60} = \frac{18}{154}$$

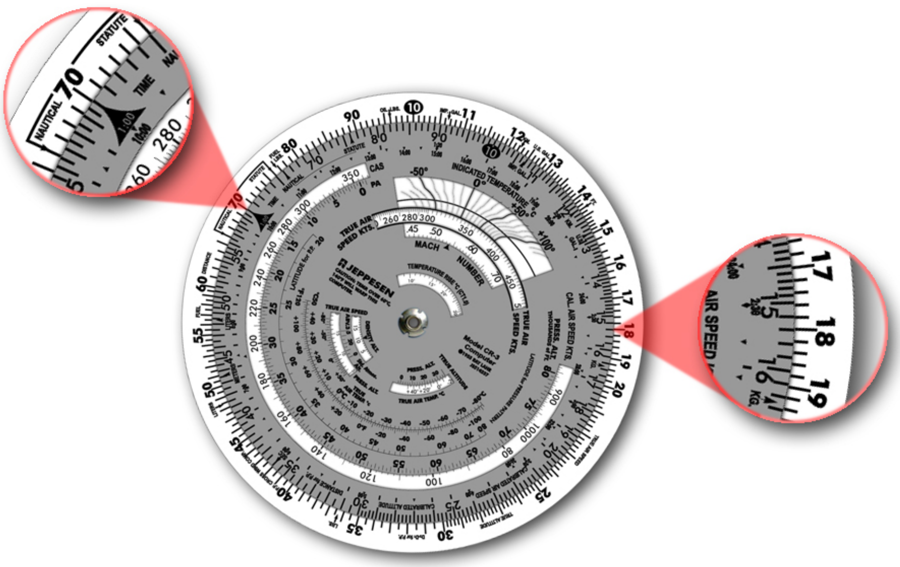
$$TE = 0.117 \times 60$$

$$TE \approx 7° \text{ Left}$$

When using the 1-in60 Rule, round the values calculated for track error and closing angle to the nearest whole degree.

Applying the formula to the Aristo computer or Jeppesen CR3:

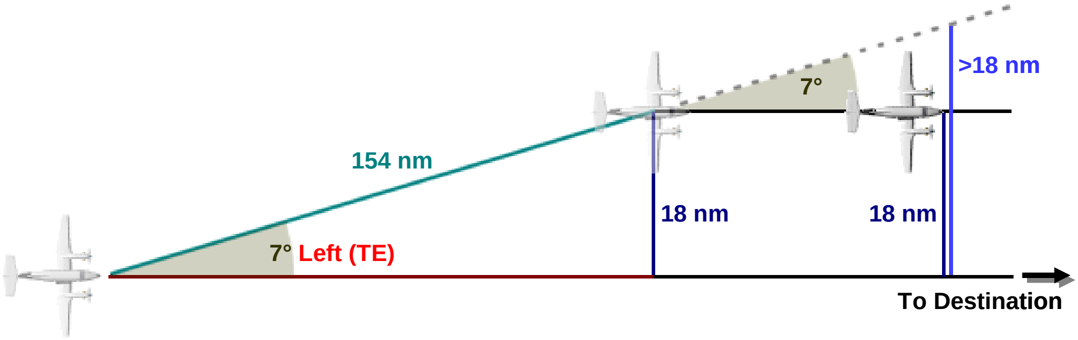




Take care when interpreting the navigation computer for the magnitude of the answer. A quick mental estimate is worthwhile doing to avoid a mistake.

If the aircraft in the example continues on its original heading, the distance off track will increase to **more than 18 nm**.

If the aircraft's heading is altered by 7° (to the right), it will arrive at its destination, and fly parallel to its original planned track.



From the example it is possible to determine track error by means of the 1-in-60 Rule (a quick "DR" method) or by means of a simple calculation in order to correct the track error and return to our planned navigation route (track).

10.4 The 1-In-60 Rule Application

Two methods available can use to make a correction to an aircraft's heading (once a track error has been determined):

- The **Correction angle to Destination** method.
- The **Double Track Error** method.

10.4.1 Correction Angle to Destination Method

Applying the Correction Angle to Destination method, both track error value and closing angle value (with the two formulas) are determined and adding it together to determine the correction angle. The correction angle represents the total correction when applied to the original heading will result in a new heading to the destination.

Alternatively, the correction angle can be described as the total correction applied to current heading in order to change the current track into the required track that leads to the planned track.

With the 1-in-60 Rule it is assume that any change in heading will result in exactly the same track change, which is accurate, as long as the heading changes are small.

Thus, if an aircraft is 18 nm left of track, after having flown for 154 nm, the track error is 7°Left.

$$\frac{\text{Track Error (TE)}}{60} = \frac{\text{Distance Off}}{\text{Distance Flown}}$$

$$\frac{TE}{60} = \frac{18}{154}$$

$$TE = 0.117 \times 60$$

$$TE \approx 7° \text{ Left}$$

If the distance to destination is 216 nm, by using the same formula (with the "Distance To-Go" value) the Closing Angle of 5° to destination is determine.

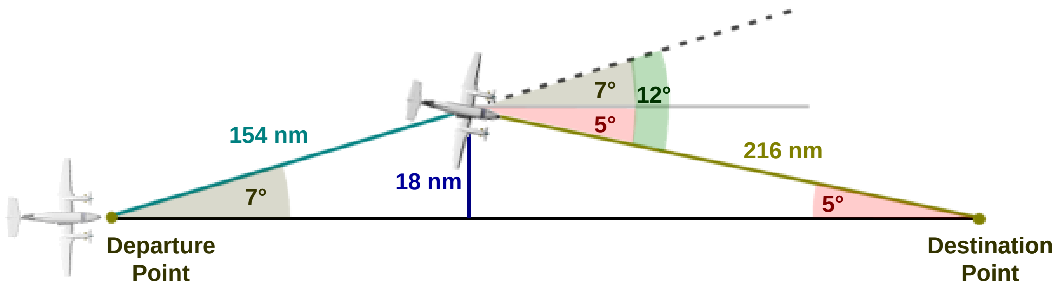
$$\frac{\text{CA (Closing Angle)}}{60} = \frac{\text{Distance Off}}{\text{Distance To Go}}$$

$$\frac{CA}{60} = \frac{18}{216}$$

$$CA = 0.083 \times 60$$

$$CA = 5°$$

The **correction angle** (or **total correction**) should be applied to the **original heading** to determine the **new heading to destination,** be **12° Right** (7° TE + 5° CA).



If the aircraft drifted off track by a strong wind when steering directly to the destination, the wind may cause the aircraft positioned to be left of destination.

This method can also be used for calculating the heading to arrive back on track within a predetermined distance.

If the flight plan track continued past the destination point and the destination point was the point at which intended to intercept the planned track, then the aircraft would need to make **another heading adjustment** as the planned track is intercepted.

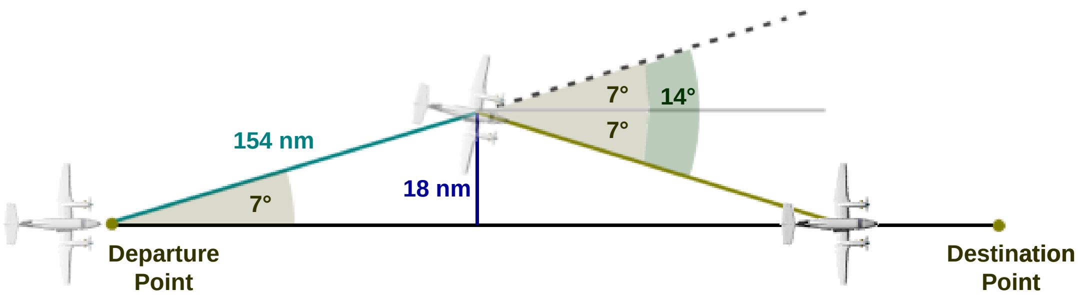
The correction required is equal to the **closing angle** and to the **opposite sense**, i.e. **change heading 5° to the left**.

10.4.2 Double Track Error Method

The Correction Angle to Destination method is a heading correction to fly directly to the destination. The Double Track Error method is what the name implies.

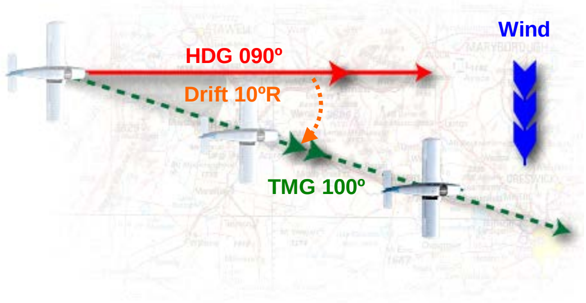
With the Double Track Error method, the heading correction is calculated by doubling the track error angle. This allows the aircraft to regain the original flight plan track (FPT) in the same distance as the distance flown. Once the FPT is regained, the heading should again be altered, in opposite direction as the first correction by the value of the original track error.

Example: The heading is altered 14° to the right (double the track error - 2 x 7°), until the original FPT is regained. At this point the heading is again altered, to the left by only 7°, the value of the original TE.



If the aircraft drifted off track by a strong wind and turning to the original heading after the original flight plan track for the destination has been regained, the aircraft will drift off track, change the heading to steer to destination accordingly. Monitor the progress and make adjustment when needed.

10.5 Finding Current Drift



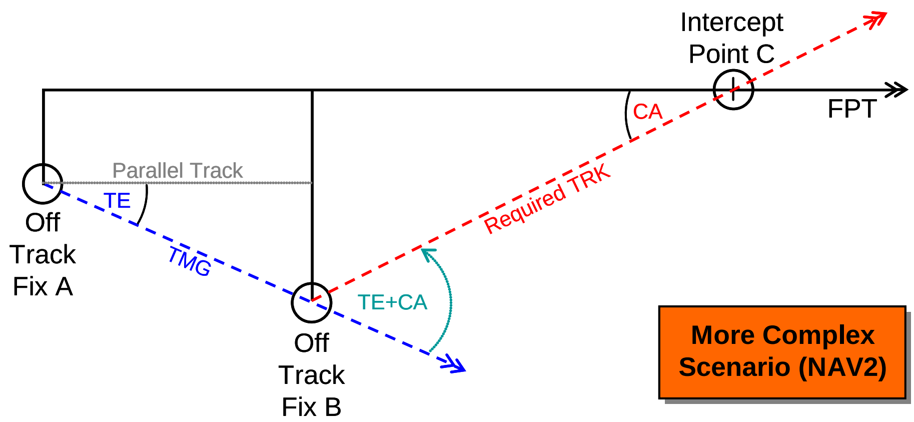
Track Error (TE) and Drift are two different concepts:

- **Track error** is the angle between the planned track and the track made good and is applied to current heading in order to parallel the planned track.
- **Drift** is the angle between the current heading and track made good. When drift is applied to the planned track, the heading to parallel track can be obtained and similarly, when current drift is applied to the required track to intercept, the heading to intercept the flight plan track can be calculated.

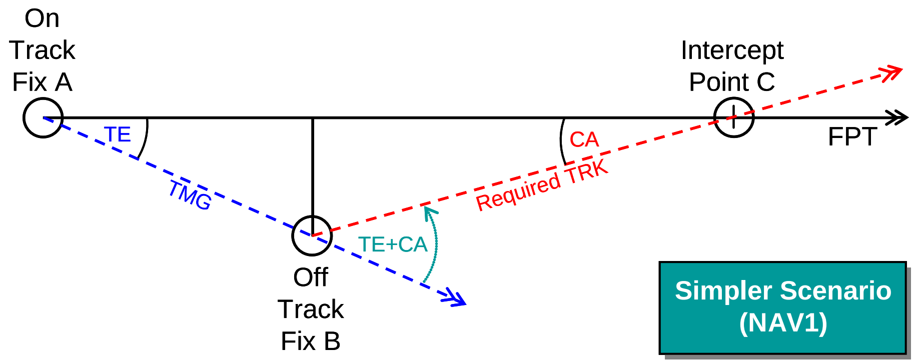
10.6 Simple and Complex 1-in-60 Rule Scenarios

The 1-in-60 Rule is important navigation techniques for single pilot VFR navigation.

More involved scenarios begins at an off track position and then the aircraft is positioned at an off track fix and the heading correction must be calculated to intercept the flight plan track.



Involved scenarios are resolved in a similar manner to the simpler scenarios, where the aircraft starts on the flight plan track and is positioned at an off track fix where the heading correction is found by calculating track error and closing angle.



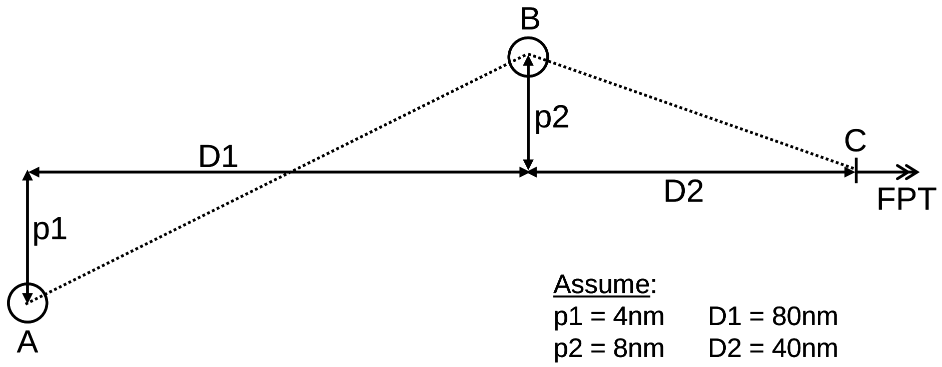
The same elements and formulae are required to find track error and closing angle.

The only difference between the two problems are that with the more complex scenarios, the triangle to solve track error must be created manually by paralleling the flight plan track through an off track fix. Care must also be taken to use the correct distance off, corresponding to the newly created track error triangle.

10.6.1 Examples of CPL Style 1-in-60 Rule Problems

Example 1: Refer to the diagram below. The aircraft was fixed overhead A at 0440UTC and altered heading to 120°M at that time to intercept the FPT of 125°M. At 0520UTC the aircraft was fixed at position B. Calculate the following

- Track Error (TE) and Closing Angle (CA)
- Track Made Good (TMG)
- Heading to Parallel FPT at B
- Heading to Intercept at C
- Heading once Intercepted at C (Heading to continue along FPT at C)
- Drift between A and B
- Updated ETA at C



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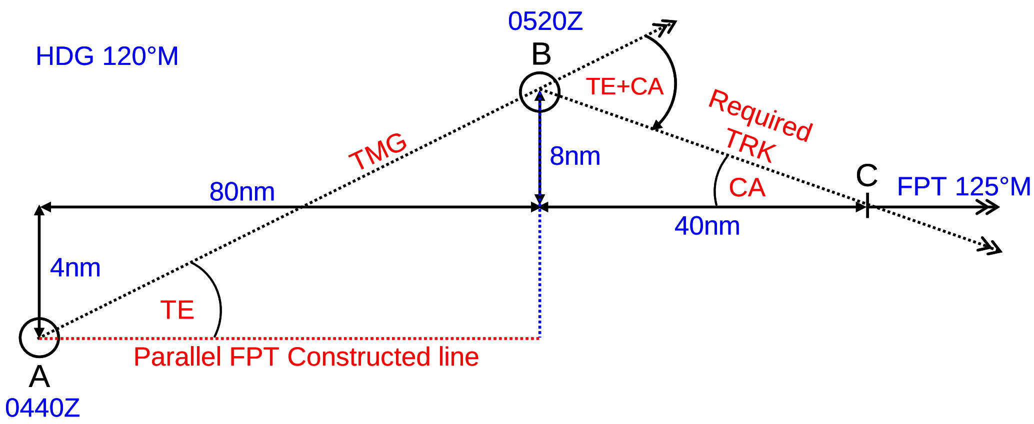
Take special care to associate the correct distances with the different parts of the diagram as indicated and if preferred, duplicate the drawing on some rough work paper.

It is also necessary to manually create the track error triangle by paralleling the flight plan track through one of the off track fixes.



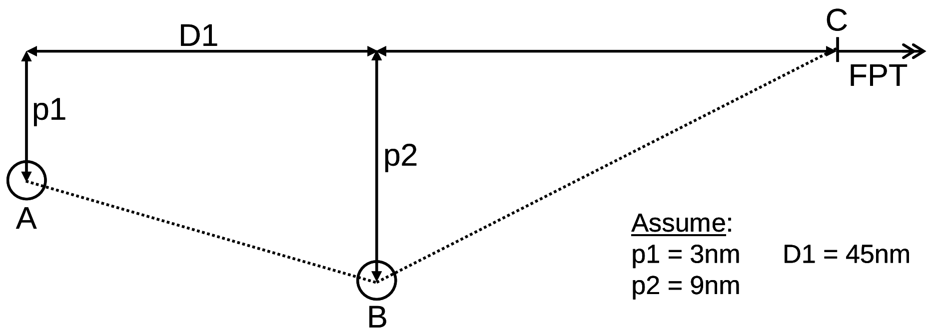
- Calculate the **Track Error (TE)** by means of the newly constructed triangle, making use of the new combined distance off (p1 + p2 = 12nm) and the distance gone (D1 = 80nm). The track error can either be solved by formula or with the nav computer. Round the answer to the nearest whole degree. **TE = 12 × 60 ÷ 80 = 9°**.
- Calculate the **Closing Angle (CA)** by means of the distance off (p2 = 8nm) and the distance to go (D2 = 40nm) and round the answer to the nearest whole degree. **CA = 8 × 60 ÷ 40 = 12°**.
- Calculate the **Track Made Good (TMG)** from the Flight Plan Track (FPT) and the Track Error (TE). Since the aircraft ended up left of track at B the TMG will be less than the FPT, so subtract the TE. **TMG = 125°M – 9° = 116°M**.
- Calculate the **Heading to Parallel the FPT at B** by applying the Track Error (TE) to the heading steered between A and B. Since the aircraft is left of Flight Plan Track (FPT) at B, the heading must be altered to the right to parallel. **Heading to Parallel = 120°M + 9° = 129°M**.
- Calculate the **Heading to Intercept at C** by applying the Closing Angle (CA) to the Heading to Parallel, or alternatively the sum of TE and CA can be applied to the heading steered between A and B to also find the intercept heading. Since in this case the aircraft is left of track, the correction needs to be to the right. **Heading to Intercept at C = 129°M + 12° = 141°M**.
- Calculate the **Heading once Intercepted at C** by applying the Closing Angle (CA) to the Intercept Heading, or alternatively the Heading once Intercepted will be equal to the Heading to Parallel at B. When applying the CA, it should be applied in the opposite sense than before. **Heading once Intercepted at C = 141°M – 12° = 129°M**.
- Calculate the **Drift between A and B** by comparing the heading steered between A and B to the actual track the aircraft had between A and B (TMG). **Drift = 120°MHDG vs 116°MTRK = 4° Left**.
- To calculate the **Updated ETA at C**, the current groundspeed is required. Calculate the groundspeed between A and B by using the distance between A and B (D1 = 80nm) and the elapsed time between the fixes (0520 UTC – 0440 UTC = 40 mins). GS = 80nm ÷ 40 × 60 = 120kts.
- Calculate the time it will take to fly from B to C from the distance between B and C (D2 = 40nm) and the groundspeed calculated earlier. Time = 40 ÷ 120 × 60 = 20 mins.
- Calculate the **ETA at C** by adding the elapsed time calculated to the time of the fix at B. **Updated ETA at C = 0520 UTC + 20 mins = 0540 UTC**.

This example illustrates some of the calculations the professional pilot can be faced with during flight to navigate the aircraft successfully.

In the CASA CNAV exam, it is not required to solve all of the above in a single scenario. Expect to solve **one of the following** scenarios:

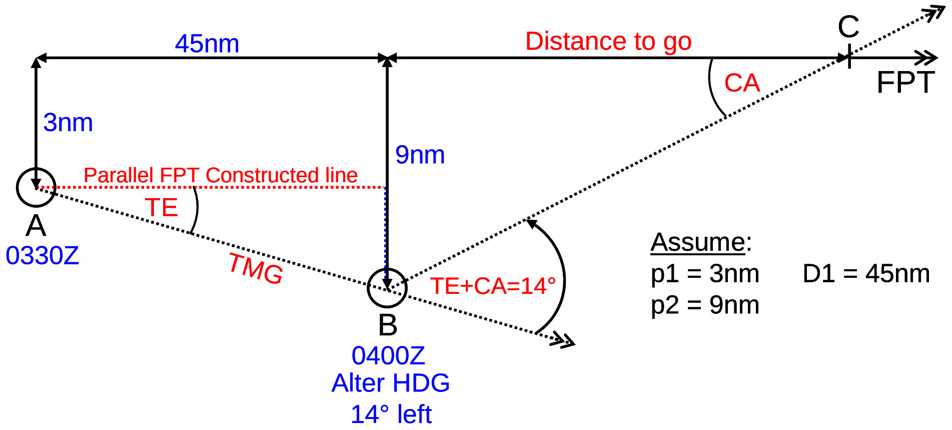
- Heading to Parallel FPT at B
- Heading to Intercept at C
- Heading to continue along FPT at C
- Drift between A and B
- Updated ETA at C

<u>Example 2</u>: Refer to the diagram below. The aircraft was fixed overhead A at 0330UTC and altered heading at that time with the intention to intercept the FPT. At 0400UTC the aircraft was fixed at position B where the heading was altered by 14° towards the left. When will the FPT be regained?



As in the previous example, ensure that the question is read properly and that all relevant information is placed on the diagram. In more complex questions, the problem may require several additional steps to be performed.

When the diagram depicts the aircraft being at an off track fix (position A), it is necessary to manually create the track error triangle by paralleling the flight plan track through one of the off track fixes. It does not matter if fix A or B is used. In the diagram below the FPT is paralleled through fix A.



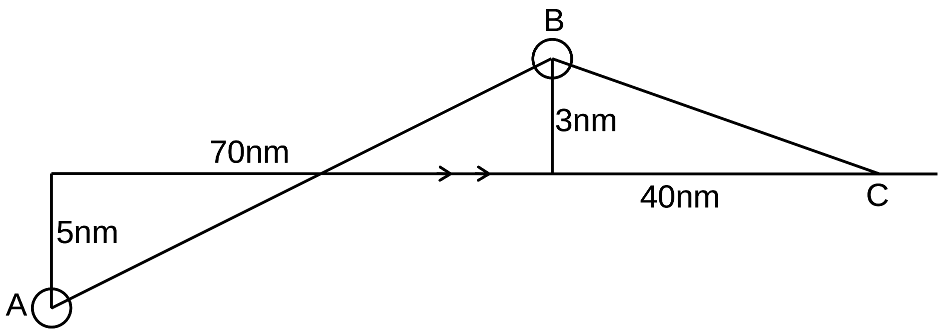
- Calculating the **Track Error (TE)** from the newly created triangle, making use of the adjusted distance off (p2 – p1 = 6nm) and the distance gone (D1 = 45nm). The track error can either be solved by formula or with the navigation computer. Round the answer to the nearest degree. **TE = 6 × 60 ÷ 45 = 8°**.
- Calculate the **Closing Angle (CA)** from the total correction performed to heading at B and the Track Error (TE) calculated earlier. Since the total correction was 14° to the left, of which 8° was for TE, **CA must be 6°**. It is not possible to calculate CA from distance off (p2 = 9nm) and distance to go, since the latter is not known.
- Calculate the **Distance to Go** from the Closing Angle (CA = 6°) and the distance off (p2 = 9nm). This is can be with the navigation computer, as the method is no different than the CA. Set the CA (6°) on the OUTER scale opposite the 1-hour triangle. Read the Distance to Go on the INNER scale, opposite the Distance Off (p2 = 9nm) on the OUTER scale. **Distance to Go = 90nm**. Alternatively the Distance to Go can be calculated by rearranging the 1-in-60 formula.
- Calculate the **Groundspeed (GS)** between A and B by using the distance gone (D1 = 45nm) and the elapsed time between the two fixes (0400 UTC – 0330 UTC = 30 mins). **GS = 45 ÷ 30 × 60 = 90kts**.
- Calculate the **Intercept Time** by using the calculated Distance to Go (90nm) and the GS (90kts). **Intercept Time = 90nm ÷ 90kts × 60 = 60mins**.
- Calculate the **ETA for C** by adding the Intercept Time (60 mins) to the time overhead the fix at B (0400 UTC). **ETA at C = 0400 + 1hr = 0500 UTC**.

Based on the specific values encountered in the example, there is of course a simplified method to calculate the final answer to this example.

Once the Distance to Go is calculated to be 90nm (double the value of the Distance travelled), it can be assumed that if it took the aircraft 30mins to travel the 45nm between fixes A and B, it will take double the time to cover double the distance (90nm), i.e. EET will be 60 mins from B to C and ETA at C is 0500 UTC.

10.7 Worksheet - 1 in 60 Rule Heading Changes

1.



A: 0140 UTC pinpoint 5nm right of track

B: 0155 UTC pinpoint 3nm left of track

What is the heading alteration at B required to regain track at C?

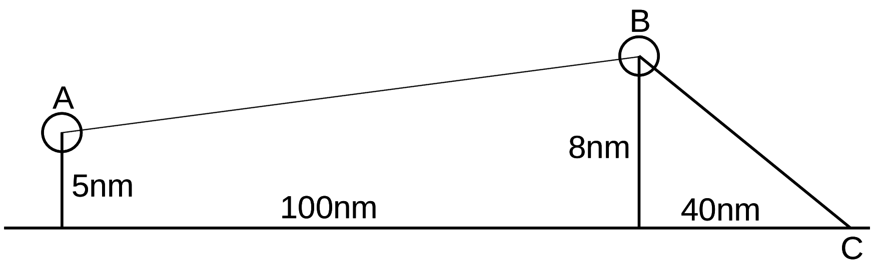
a. 10° left

b. 10° right

c. 12° left

d. 12° right.

2.



A: 0200 UTC pinpoint 5nm left of track

B: 0238 UTC pinpoint 8nm left of track.

What is the heading alteration, at 0238 UTC, to intercept track at C?

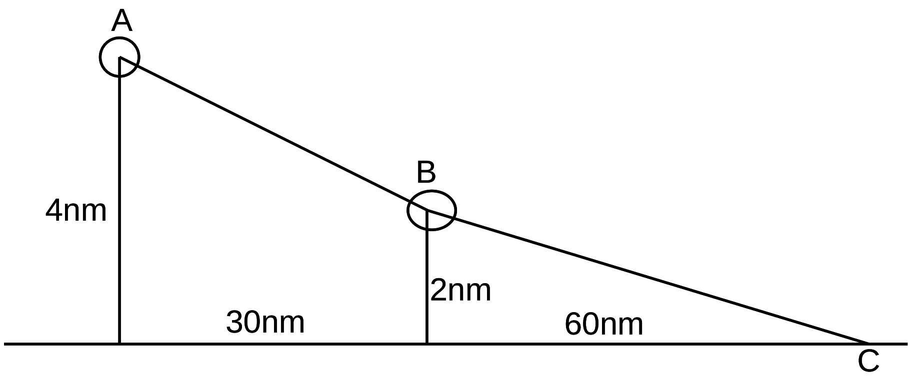
a. 14° left

b. 15° left

c. 14° right

d. 15° right.

3.



A: 0100 UTC pinpoint 4nm left of track

B: 0155 UTC pinpoint 2nm left of track

What is the heading alteration at B required to regain track at C?

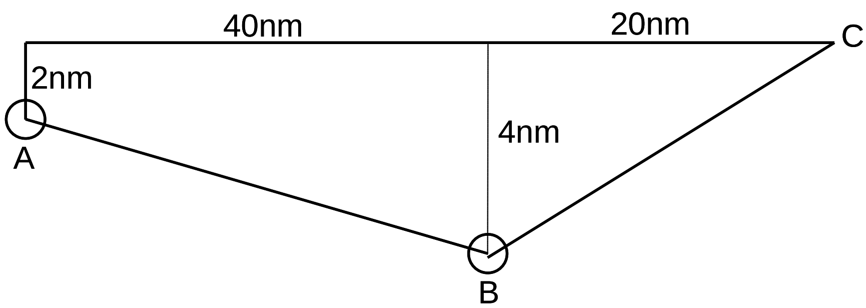
a. 6° right

b. 2° right

c. 6° left

d. 2° left.

4.



A: 0100 UTC pinpoint 2nm right of track. HDG 090°M

B: 0120 UTC pinpoint 4nm right of track. HDG 090°M

What is the heading required to regain track at C?

a. 072°M

b. 075°M

c. 102°M

d. 105°M.

5. In the following diagram, the track between X and Y has been marked at 10nm intervals. The total distance between X and Y is 50nm. The aircraft was on time over X but is now 2 minutes late at position A. If the planned ETA at Y was 0030Z, what is the revised estimate?

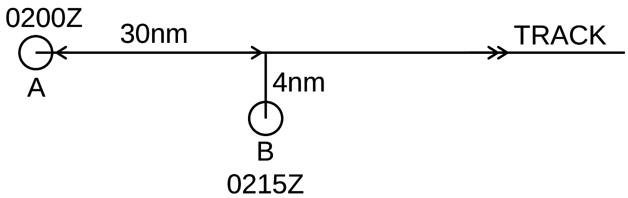
a. 0032Z

b. 0033Z

c. 0035Z

d. 0038Z.

6. In the following diagram, the aircraft at B alters heading to the left by 14°.



At what time will track be regained?

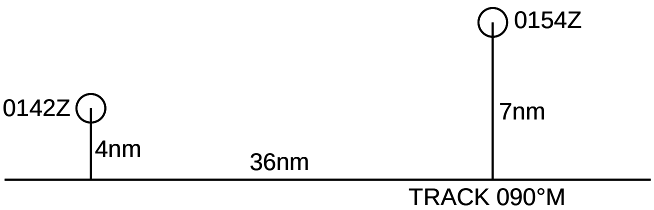
a. 0230Z

b. 0235Z

c. 0240Z

d. 0245Z.

7. In the diagram below, the aircraft maintained a constant TAS and a constant heading of 082°M from 0142Z to 0154Z.



What drift was experienced between 0142Z and 0154Z?

a. 3° left

b. 5° left

c. 3° right

d. 5° right.

8. An aircraft cruising at A050 is required to descend to a circuit height of 1000 feet over YBAB. If the rate of descent is 600 ft/min and the GS during descent is 120 knots, at what distance from YBAB should descent be commenced?

   a. 12nm

   b. 13nm

   c. 15nm

   d. 20nm.

10.7.1 Worksheet Answers

1D	2C	3D	4B
5C	6B	7C	8A