AN IMPORTANT NOTE ABOUT ACCURACY IN CALCULATIONS

CASA expect *extreme accuracy* in all calculations and take-off or landing charts. The level of accuracy required is far beyond what would be considered acceptable in the 'real world'.

When performing multi-step calculations, you should keep all intermediate decimal places on your calculator and then round the final answer to the nearest *appropriate* whole number.

What do I mean by *appropriate* whole number? Glad you asked that one.

For **minimum fuel or ballast required** calculations, round *up* to the next whole number.
If there is any decimal place in the final answer, the answer should be rounded up.
So 167.1745 gallons should be rounded up to 168 gallons.

For **maximum weight limitations** calculations round *down* to the next whole number.
If there is any decimal place in the final answer, the answer should be rounded down.
So 167.8745 kg should be rounded down to 167 kg.

Otherwise, if the first decimal place in the final answer is 5 or more, the answer should be rounded up. So 167.5475 should be rounded up to 168 and if the first decimal place is less than 5, the answer should be rounded down. So 167.4475 is rounded down to 167.

The examiner will make it clear as to which way the final answer is to be rounded.

Since CASA does not disclose how much margin of error is allowed for people who choose to do multiplication or division on a flight computer e.g for PNR, ETP or time, speed and distance calculations, it is strongly recommended that you use an electronic calculator for all operations except for flight planning headings and ground speeds and conversions between CAS and TAS.

Also, extreme care must be taken when using any take-off or landing performance chart. Make sure that you have a sharp pencil (and invest in a pencil sharpener). Make sure that all horizontal and vertical lines are precise. Take great care in interpolation between published values. Very little deviation is permitted from CASA's 'perfect answer'.

Calculations in this book have been presented as follows.

Single step calculations
The answer is taken to the nearest appropriate whole number.

Multi-step calculations
Intermediate calculations are taken carry at least one decimal place with the final answer shown to the nearest appropriate whole number.

(Intermediate decimal places are not shown in the text for the sake of brevity.)

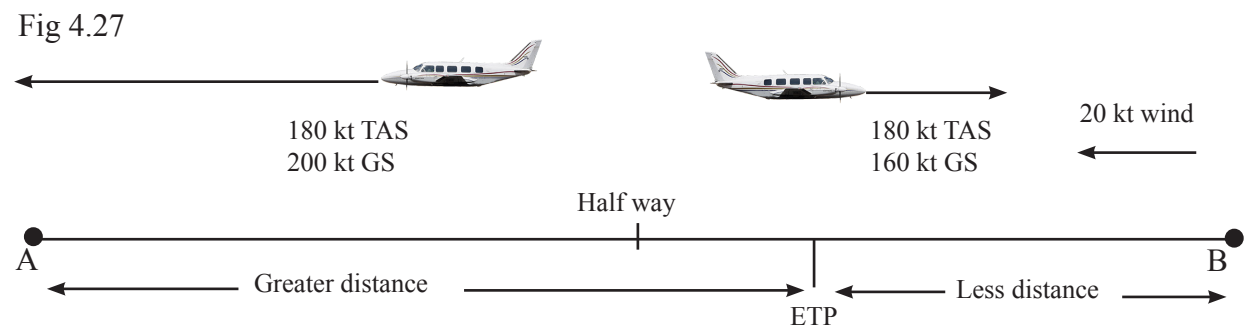## THE EQUI-TIME POINT [ETP] also called CRITICAL POINT - [CP]

The Equi - Time Point [ETP] is also sometimes called the Critical Point [CP]. It is simply the point along a given route segment from which it will take the same time to go on, or return to the starting point. This point would be of interest to pilots who are planning a flight which involves a long segment over desolate country with no suitable aerodromes en-route where a landing could be made in the event of an emergency, a long segment over water, or an IFR or NGT VFR flight with no en-route aerodromes equipped with appropriate navigation aids or lighting. Once the ETP has been calculated, it becomes one of the factors that must be considered in an emergency. If an emergency arises before the ETP has been reached, it will be faster to go back to the departure point. If an emergency arises after the ETP has been passed, it will be faster to continue to the destination.

Obviously, if there was no head or tail wind component along track, the ETP would be half way.

Fig 4.26

No wind

180 kt TAS
180 kt GS

180 kt TAS
180 kt GS

A

ETP
Half way in no wind

B
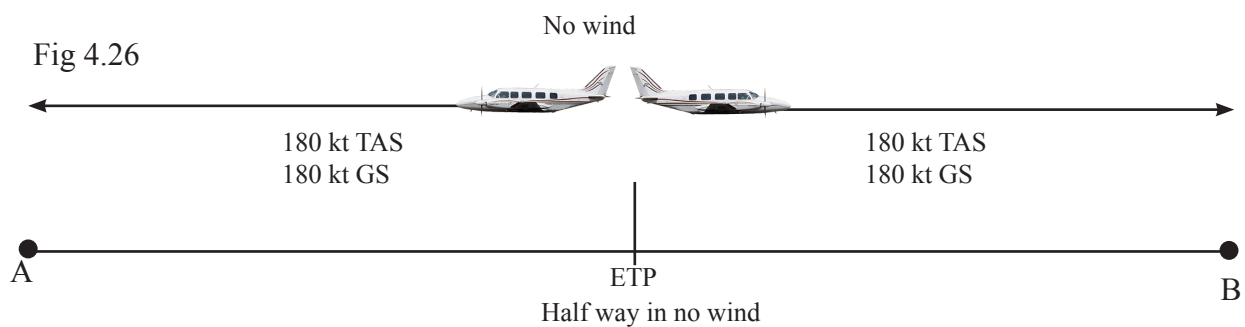
In the example illustrated in Fig 4.26 above, for an aircraft with a TAS of 180 kt, the ETP would be half way between A and B in no wind. It would take the same time to fly from the ETP to A as it would to fly from the ETP to B.

If we now consider wind component of 20 kt blowing from B to A, what will happen to the ETP ?

Fig 4.27

180 kt TAS
200 kt GS

180 kt TAS
160 kt GS

20 kt wind

Half way

A

Greater distance

Less distance

ETP

B

If we continue towards B, the ground speed will be 160 kt, if we return to A, the ground speed will be 200 kt. It follows that the ETP must be closer to B since the time taken to fly from the ETP to B at 160 kt must equal the time taken to fly from the ETP to A at 200 kt [fig 4.27].

THE ETP [also called CP] WILL ALWAYS BE HALF WAY IN NO WIND.

IF A WIND EXISTS, THE ETP WILL ALWAYS MOVE UP-WIND FROM HALF WAY.

The ETP calculation.

To continue with this example, let's assume that the total distance from A to B is 350 nm. To calculate the actual position of the ETP between A and B we need to know three things.

1. The ground speed we expect if we choose to continue on to B   [GS on]
2. The ground speed we expect if we choose to return to A   [GS home]
3. The total distance between A and B

In this example,

GS on	=	160 kt
GS home	=	200 kt
Total distance	=	350 nm

The ETP formula is,

$$\textbf{Distance to ETP} = \frac{\textbf{Total distance x GS home}}{\textbf{GS home + GS on}}$$

$$= \frac{350 \times 200}{200 + 160}$$

$$= \frac{70000}{360}$$

$$= \quad 194 \text{ nm from A}$$

Fig 4.28

20 kt wind

GS home = 200 kt   GS on = 160 kt

350 nm

A   B
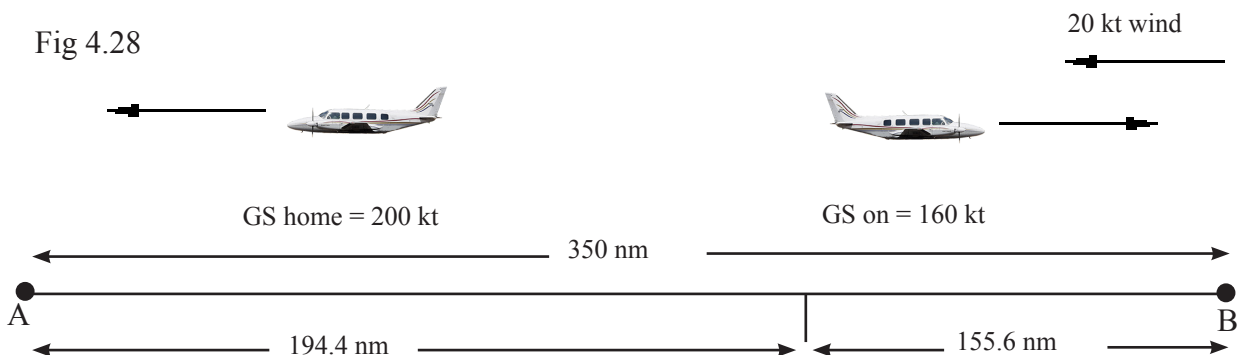
194.4 nm   155.6 nm

Proof:

The time to fly from the ETP to B is 155.6 nm @ 160 kt   =   58.3 min

The time to fly from the ETP to A is 194.4 nm @ 200 kt   =   58.3 min

Note that even though the examination does not require it, you can always prove that the ETP you have calculated is correct. I think it is a good idea to do this in the first few exercises that you try to ensure that you are not just blindly using a formula, but that you understand what the answer means.

Computer solution:

Fig 4.29

To solve the ETP calculation on your computer, simply place the sum of the ground speeds on the inside scale beneath the total distance on the outside [Fig 4.29].

Place the sum of the ground speeds (360) beneath the total distance (350)

Read the distance to the ETP (194) against the GS home
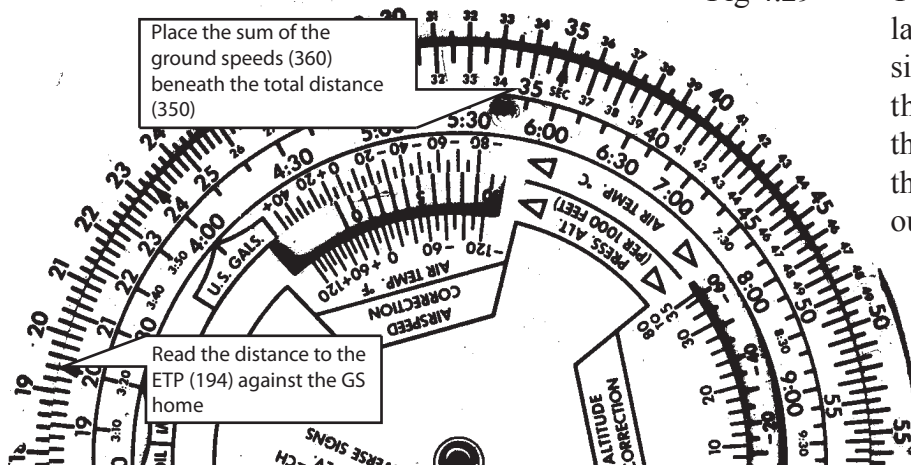
The distance to the ETP is read against the GS home on the inside scale. Note also that when the wind is given as *a headwind component directly along the flight planned track,* the GS on is actually TAS minus the wind, and the GS home is the TAS plus the wind,

$$\text{GS on} + \text{GS home} = [\text{TAS} - \text{wind}] + [\text{TAS} + \text{wind}]$$
$$= 2 \times \text{TAS}$$

A simplified version of the ETP formula when the wind is given as a head or tailwind component directly along the flight planned track becomes-

$$\textbf{Distance to ETP} = \frac{\textbf{Total distance} \times \textbf{GS home}}{\textbf{2} \times \textbf{TAS}}$$

However, if the wind is given as a velocity instead of a component, you will need to calculate the two ground speeds on your flight computer.

### SINGLE ENGINE ETP FOR MULTI-ENGINE AEROPLANES.

If you do a multi-engine endorsement, you will need to know how to calculate a ETP which assumes that, in the event of an engine failure en-route, the aircraft will be flown either on to B on the one remaining engine, or back to A on the one remaining engine.

To calculate this point we simply use the same formula except that the TAS we consider is the single engine TAS. Assuming the aircraft we have been considering has a single engine TAS of 110 kt, the distance to the single engine ETP is [See Fig 4.30]:

Fig 4.30

$$\text{Dist to SE ETP} = \frac{\text{Total distance} \times \text{SE GS home}}{2 \times \text{SE TAS}} = \frac{350 \times 130}{220} = 206.8 \text{ nm from A}$$
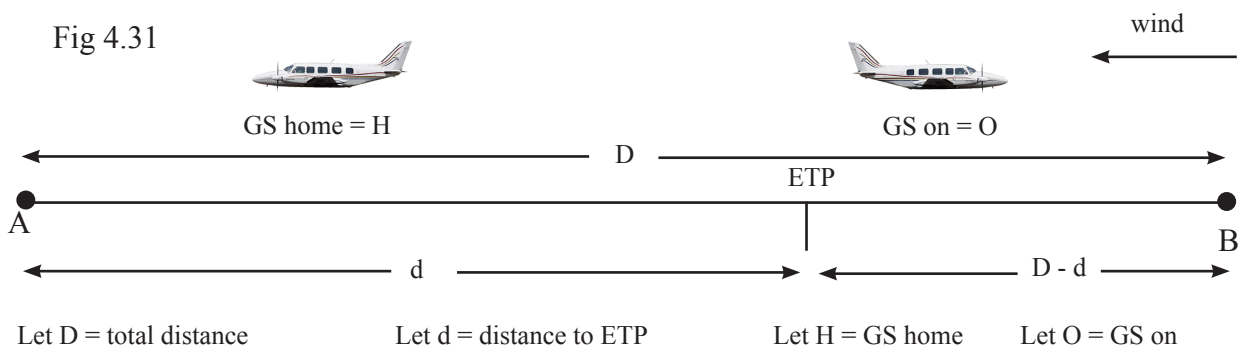
Proof:

20 kt wind

SE GS home = 130 kt   SE GS on = 90 kt

350 nm
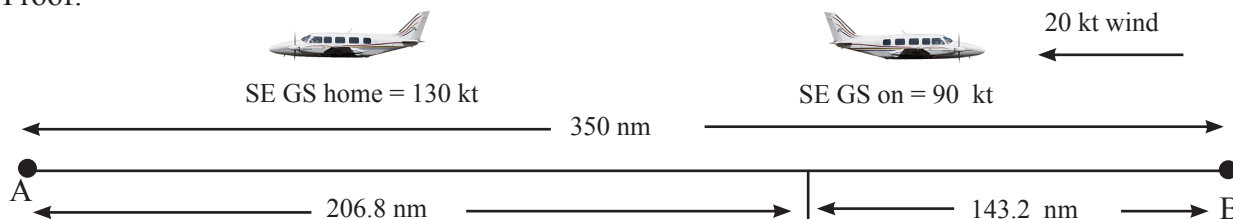
A ——— 206.8 nm ——— | ——— 143.2 nm ——— B

Time to fly from the ETP to B on one engine is 143.2 nm @ 90 kt   =   95.4 min
Time to fly from the ETP to A on one engine is 206.8 nm @ 130 kt   =   95.4 min

Deriving the ETP formula from basic principles.
For those of you with a love of maths, here is the derivation of the ETP formula [Fig 4.31].
This is not required knowledge for the examination.

Fig 4.31

GS home = H   GS on = O   wind

Let D = total distance   Let d = distance to ETP   Let H = GS home   Let O = GS on

If the times are to be equal,

$$\frac{d}{H} = \frac{D - d}{O}$$

so

$$\frac{d}{H} = \frac{D}{O} - \frac{d}{O}$$

and

$$\frac{d}{H} + \frac{d}{O} = \frac{D}{O}$$

$$d \left(\frac{1}{H} + \frac{1}{O} \right) = \frac{D}{O}$$

$$d \left(\frac{HO}{H} + \frac{HO}{O} \right) = \frac{D \times HO}{O} \quad \text{[Multiplying both sides by HO]}$$

$$d \, [\, O + H \,] = D \times H$$

$$\text{and} \quad d = \frac{D \times H}{O + H} \quad\quad \textbf{AMAZING EH ?}$$

Before we go further, make sure you are familiar with the flight computer solutions for flight planning heading and ground speed for a given TAS, wind and flight planned track.

Here is an example.

Flight Planned Track	040°M
Forecast wind from	120°T at 20kt
Magnetic variation	10°E
True Air Speed	180kt

Consider this example. You are to fly outbound on the 040°M track and then turn around and fly back home on the reciprocal track of 220°M. Find the ground speed to expect outbound and also on the return trip (we are not interested in the heading in this example). The wind is given as a *velocity*, not a *head or tail wind component*, so you must calculate the ground speeds on your flight computer.
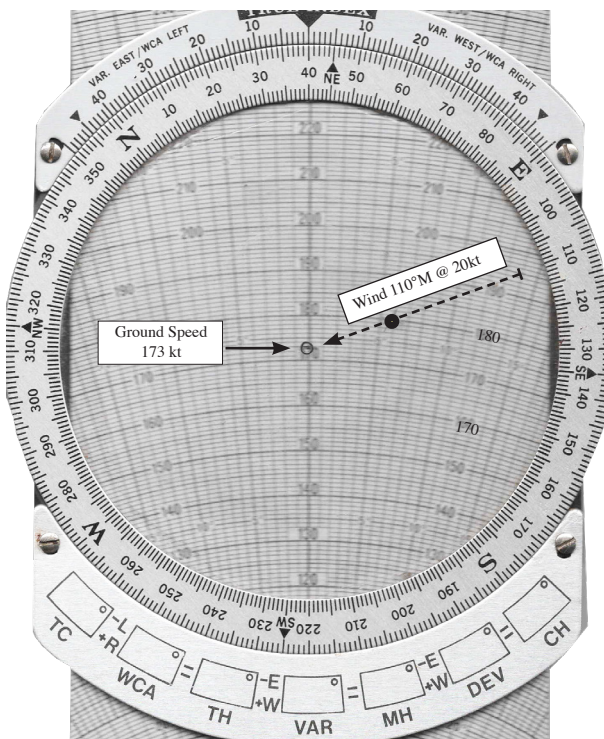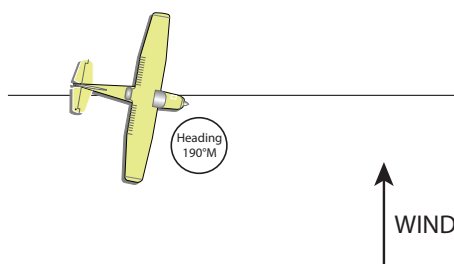

Ground Speed out 173kt
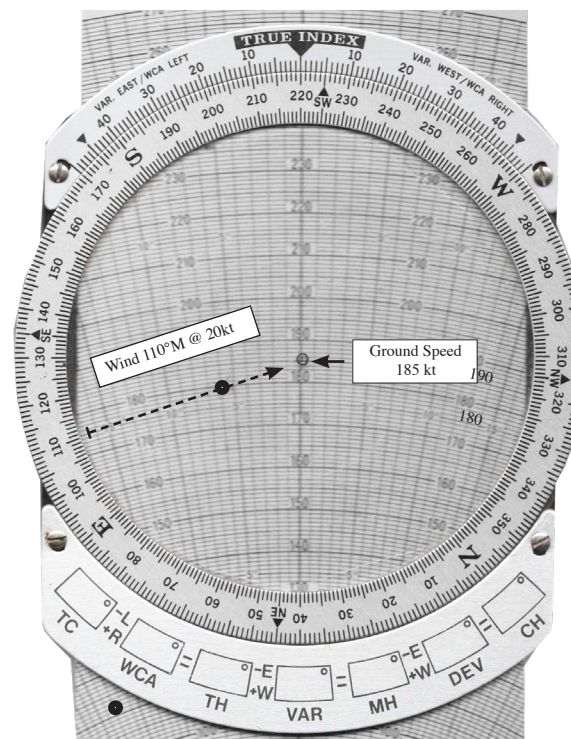
Ground Speed back 185kt

Now consider an extreme example. A strong wind is at exactly 90° to the flight planned track. A common misconception is that, if the wind is at 90° to the track, there would be no head or tailwind component and the ground speed would be the same as the TAS.


This is not the case however, because when the wind is at 90° to the track, it is necessary to fly into wind to counter the drift.

So there *will* be a headwind component and the ground speed will actually be **less** than the TAS.

Here is an example of a strong wind at right angles to track

.

|	
Flight Planned Track	330°M
Forecast wind from	250°T at 40kt
Magnetic variation	10°E
True Air Speed	150kt

You are to fly outbound on the 330°M track and then turn around and fly back home on the re-ciprocal track of 150°M. Find the ground speed to expect outbound and also on the return trip (we are not interested in the heading in this example).
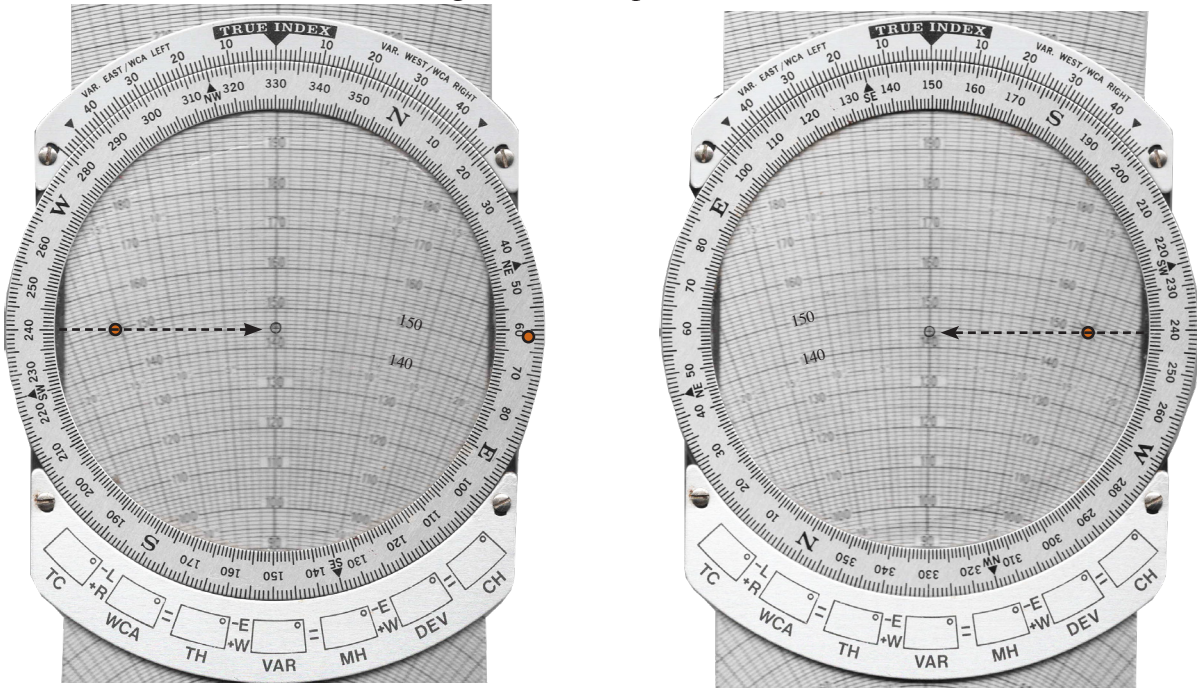
With the wind at right angles to track some might reason that, since there is no head or tail wind component acting along the track, the ground speed should be the same as the TAS. As we have seen that is not true. In this example, the ground speed is 5 knots *less* than the TAS (145kt). That is because the heading is 15° further into wind than the track so the aircraft must fly into wind to allow it to remain on track.

Solving the same example on a circular computer.

1
Set the TAS (150).
Set the wind(240 at 40kt).
Set the FPT (330).
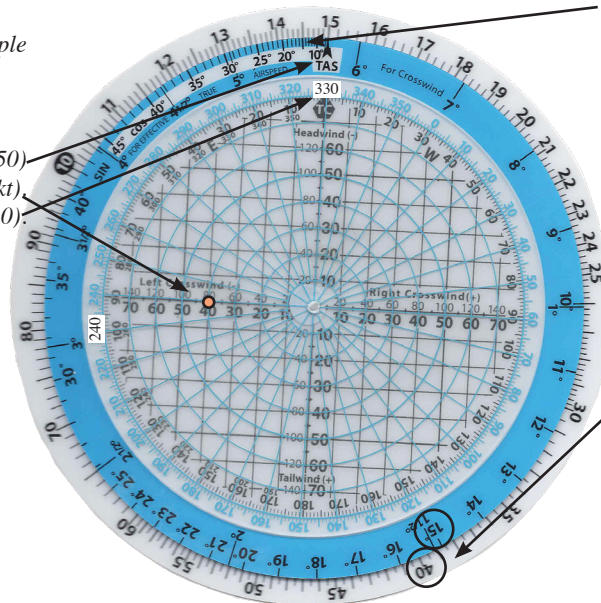
3
Find 15° on the effective TAS window and read the corresponding effective TAS (145). Add or subtract the head or tail wind component to or from the effective TAS to find the ground speed.

*There is no head or tail wind component on the FPT, so 145kt is also the ground speed.*

2
The crosswind component is 40kt. So find 40kt on the outside scale and convert it into a drift angle (15°).
If the drift is greater than 10° you need to find effective TAS (See 3).

As we cover equi-time point and point of no return calculations in this chapter, we will often need to calculate the ground speed to expect on the outbound leg of a flight as well as the ground speed to expect if we decide to return to out starting point. Sometimes we will need to *add those two ground speeds together.*

Of course if there is no wind at all, the ground speed will be the same as the TAS in both directions. However, if a wind is introduced, we will have to consider the effect it will have on the ground speed.

There are two ways that an examiner can describe the wind. It can be given as a headwind or tailwind *component* on track. In that case we simply apply the wind component to the TAS to obtain the ground speeds. Add the wind component to the TAS if it is a tailwind and subtract the wind component from the TAS if it is a headwind.

For example, for a TAS of 180kt and a 20kt headwind component, the ground speed outbound would be 180 - 20 = 160kt, while the ground speed on the return leg would be 180 + 20 = 200kt

180 kt TAS	180 kt TAS	20 kt wind
200 kt GS	160 kt GS	

A   B
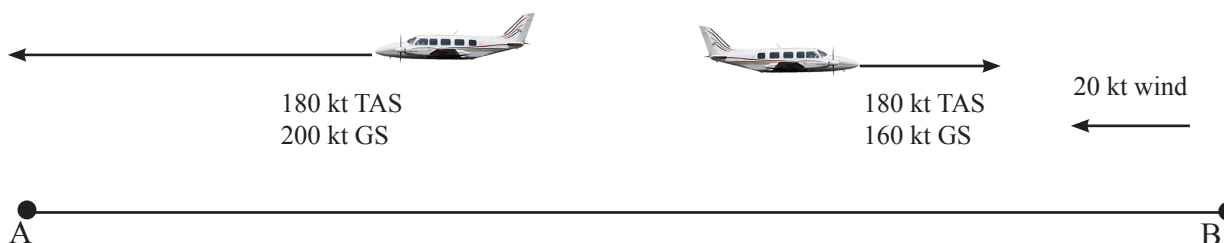
In this case, if you added the two ground speeds you would get-

Ground speed out	= TAS - wind component
Ground speed home	= TAS + wind component
Sum of the ground speeds	= TAS + wind component + TAS - wind component
	= 2 x TAS (the two wind components cancel out)

However, if the wind is given as a *velocity* (direction and speed) in a direction other than directly along the track, the sum of the ground speeds will not be the same as 2 x TAS. In that case, you will need to calculate the ground speeds on a flight computer as shown previously. This is especially important when the wind is strong and at a large angle to track.

In the example worked on the previous page, the ground speed out is 145kt and the ground speed home is also 145kt so the sum of the ground speeds is 290kt whereas 2 x TAS is 300kt. That's enough to give you an incorrect answer in an exam.

So remember:

If the wind is given as a <u>headwind or tailwind component along track</u>, the sum of the ground speeds will simply be 2 x TAS.

If the wind is given as a velocity (direction and speed) at an angle to track, you must <u>calculate the two ground speeds on a flight computer</u> and then find their sum.

## AN EXAMPLE OF A SINGLE-ENGINE CRITICAL POINT CALCULATION.

An aeroplane is planning a flight from A to B. The flight planned track is 128°M and the distance A to B is 435 nm. The normal two engine cruising TAS is 150kt. If the single engine TAS is 80 kt. The GAF indicates that a wind of 45 kt from 200°T is expected on the flight planned track at all levels. If the magnetic variation is 8°E, find the distance from A to the single engine ETP [ignore climbs and descents].

The wind is given as a vector, so you must calculate the single engine ground speed out and home

Find the single engine ground speed out (also called ground speed on).
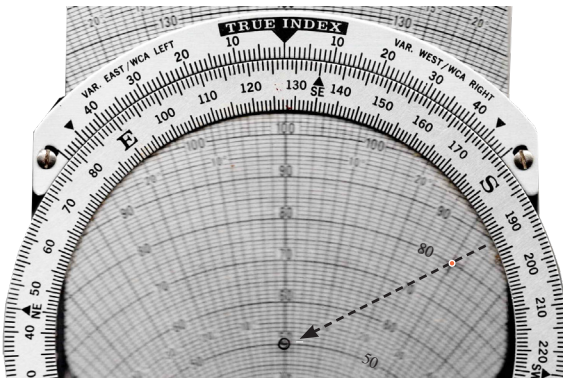
Wind 192 @ 45kt. TAS 80kt
Single engine ground speed out = 50kt (under the grommet)
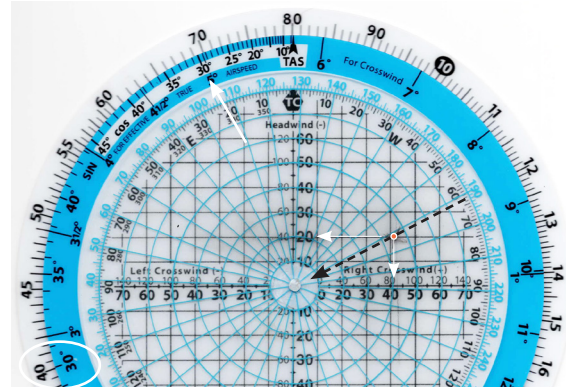
Wind 192M @ 45kt. Cross wind 40. Headwind 20. TAS 80kt
Drift angle 30°. Effective TAS 70 minus the headwind 50kt
Single engine ground speed out = 50kt.

Find the single engine ground speed back (also called ground speed home).
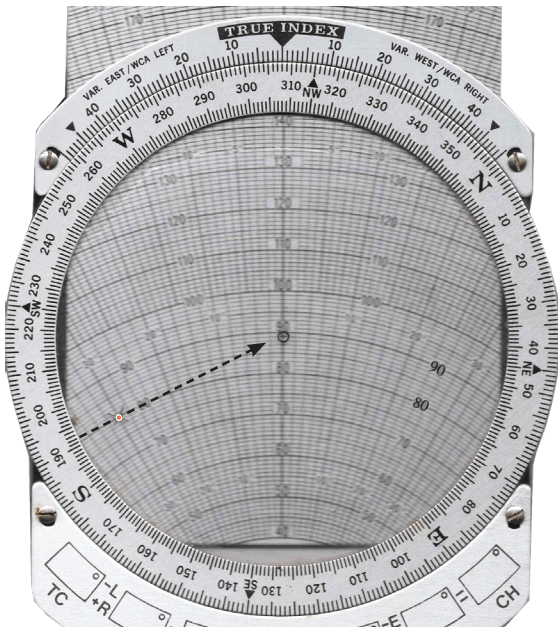
Wind 192 @ 45kt. TAS 80kt
Single engine ground speed home = 89kt (under the grommet)
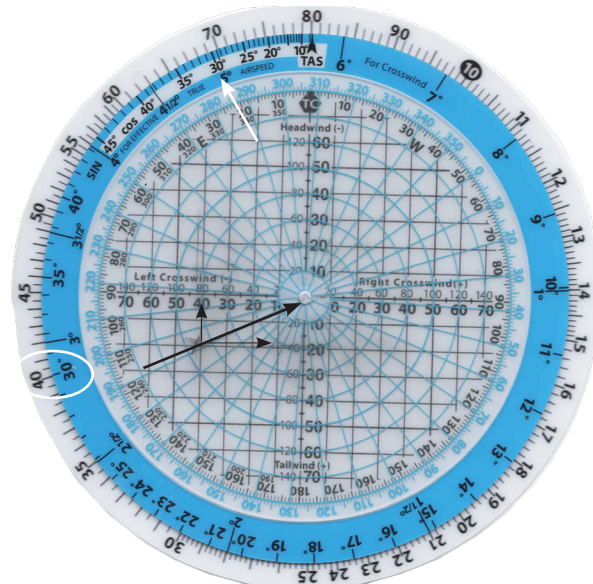
Wind 192M @ 45kt. TAS 80kt. Crosswind 40. tailwind 20.
Drift angle 30°. Effective TAS 69 plus the tailwind 89kt
Single engine ground speed home = 89kt.

SOLUTION.

Single engine GS on is	= 50 kt.
Single engine GS home is	= 89 kt
Total distance	= 435 nm
Distance to single engine critical point	= 435 x 89 ÷ 139 = 278.5nm (279nm)

Now that we know where the critical point is, how will we know when we have arrived there? If good visual features are not available, one of the most useful indicators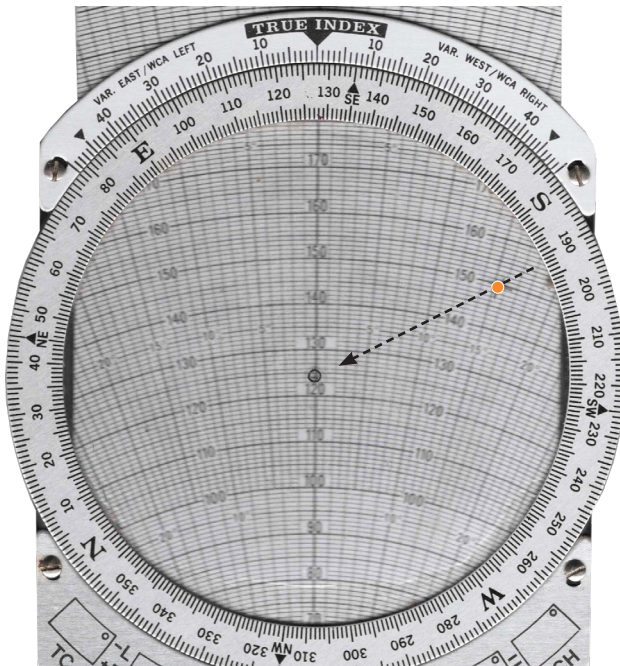 would be the time it should take to get there. After you have calculated the ETP, you may often want to know the time it will take get to that point.

If we return to the example above, and assume that the flight planned TAS for normal two engine cruise was 150 kt, then the flight planned GS from A to B would be.

Track 128°M
Wind from 192°M at 45kt
TAS 150kt
Ground speed 125kt (under grommet)

Ground speed out at normal cruise TAS

= 125kt

Time to the ETP at normal cruise on 2 engines   = 279 nm @ 125kt
                                                   = 133.9 (134min)

SOME IMPORTANT POINTS TO CONSIDER FOR MULTI-ENGINE AEROPLANES.

In the event of an engine failure before that time, we know it would be faster to go back. In the event of an engine failure after that time, it would be faster to continue on to B.
Note that the ETP simply tells us whether it would be faster to go on or to go home. However the fastest option may not necessarily be the safest option!

I suggest you read carefully CAO 20.6.3.2

Consider an IFR flight which has just passed through an area of thunderstorm activity with associated severe turbulence and icing. If an engine failed and the ETP had not been reached, it would be faster to go back - but you would have to be crazy to try it!

Don't forget that the altitude you can expect to maintain on one engine is likely to be much lower than your original planned cruise altitude [typically about 5000ft density height for most light twins]. Even though the ETP calculation may indicate that it is faster to go on after an engine failure, there is not much use trying if you can't maintain terrain clearance.

As is so often the case in aviation, there are many factors that must be considered - the ETP is just one of them.

Fig 4.32

Original cruising level

Single engine ceiling

Engine
failure !

Engine
failure !

GOING BACK ?

Fig 4.32a

Engine
failure !

GOING ON ?
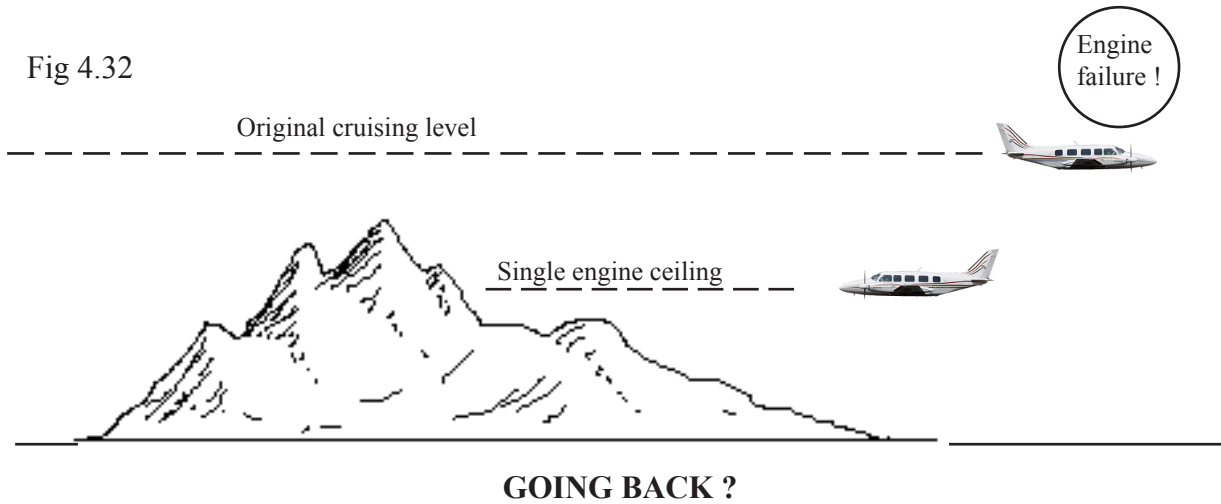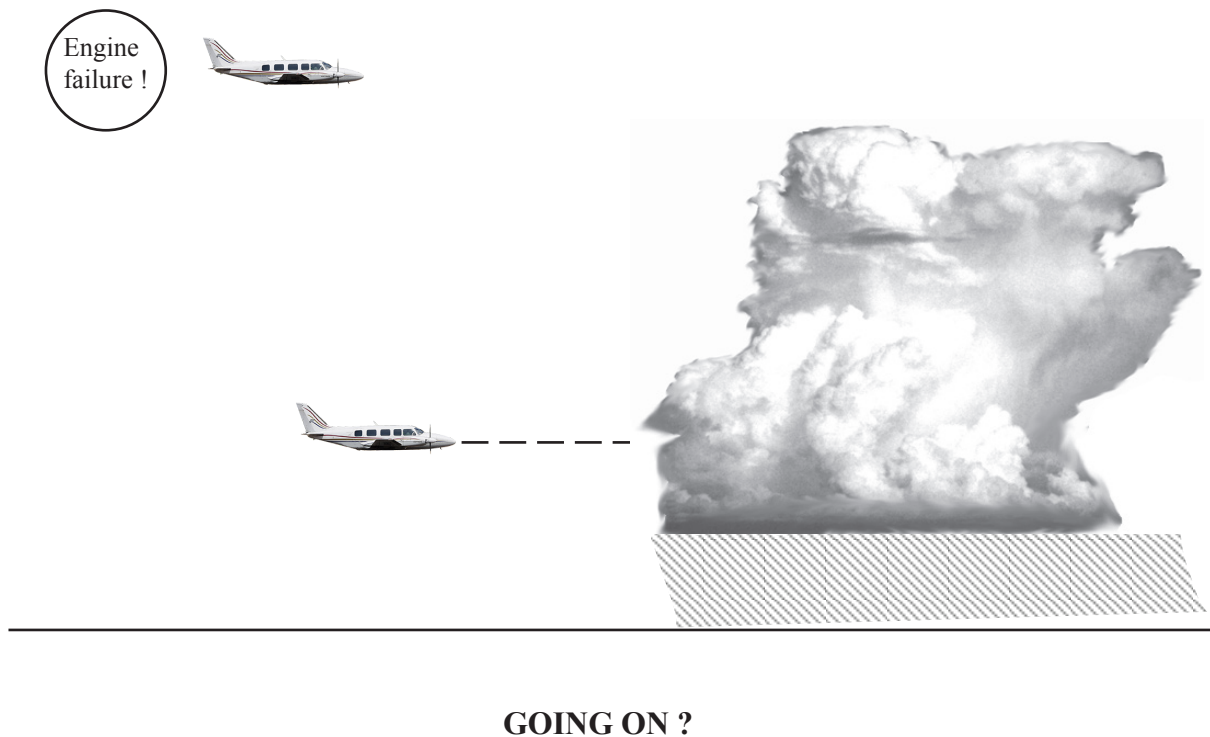
Then there was the young pilot who was flying a Chieftain from a major airport to a country homestead. The weather was fine and beaut and there were no terrain problems on the short flight. When the left engine failed, the pilot decided that, since he had passed the single engine ETP, the best thing to do was to continue on to the ALA, where he successfully landed. The phone call to his boss went something like this.

Pilot: "I had the engine failure, and since I had already passed the critical point, I continued on to land out here.

Boss: " I've got news for you buddy, you've just passed a critical point in your career- you're fired!"

CALCULATING THE POINT OF NO RETURN. [PNR]

The PNR is the maximum distance an aircraft can proceed in a given direction from its take off point before it becomes impossible for it to return with all reserves intact. It is obvious then that if all other factors remain constant, the distance to the PNR is governed by the amount of fuel on board at start up.

The first step in finding the PNR is to calculate the time that the aircraft can fly without using its fuel reserves. This time, expressed in minutes, is called the safe endurance.

FINDING THE SAFE ENDURANCE

Let's investigate the safe endurance available for an aircraft on a CHTR flight if start up is with 180 gal, fuel flow is 28 gph, and the allowance for taxi and fixed reserve is 3 gal and 15 gal respectively.

Total fuel at start up	= 180 gal
Less start up and taxi allowance	= 3 gal
Less fixed reserve	= 15 gal
	= 162 gal
162 gal is 110% of the trip fuel available so 100% of the trip fuel	= 147.3 gal
Fuel flow	= 28 gph
147 gal @ 28 gph	= 315.6 min
Safe endurance	= 316 min

> **TO FIND THE SAFE ENDURANCE** :
>
> 1. FIND THE Trip fuel AVAILABLE.
> 2. CONVERT THE Trip fuel TO MINUTES AT CRUISE RATE.

In the CPL examination all questions on PNRs are based on normal two engine operations both out and back. Engine failure is not considered in the PNR calculation. Also a flight that has flown to its PNR and is returning to base is not considered as an emergency. Such a flight would be expected to have all the fuel reserves, including holding due weather, required by the operator and/or the CASA. No special consideration or priority would be given to the issue of airways clearances or traffic sequences.

Considering the example for the aircraft given above, the flight to the PNR and back to base must not be any longer than 315 mins.

Fig 4.33

Departs with full tanks

Arrives back at base after 315 min with all reserves intact.

Base   PNR
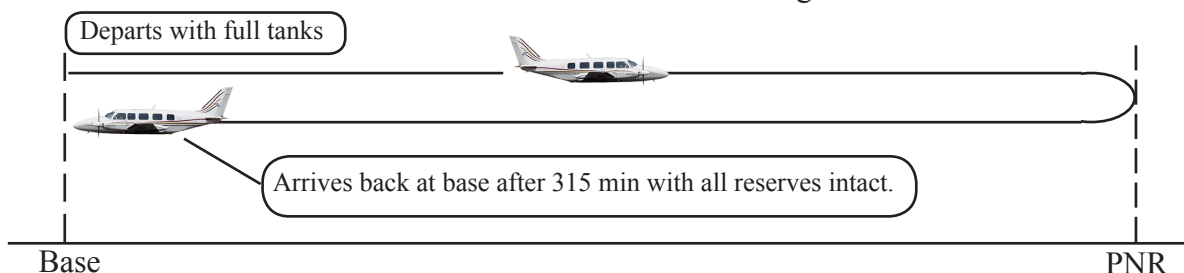
THE EFFECT OF WIND.

Continuing with this example, if there is no wind, the ground speed out to the PNR will be the same as the ground speed home. It follows that since the flight out and back must be 316 mins, the time to the PNR must be half of 316 [158] min. If there is no wind, the aircraft can fly out until half of its safe endurance is used - it must then return to base.

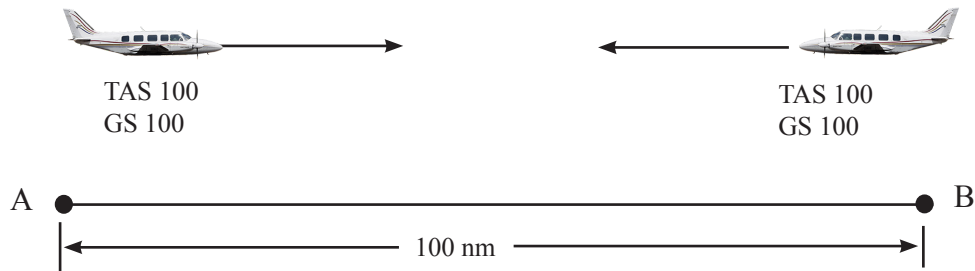What happens if we introduce a wind? Now here's a chance to win some bets in the aero club bar! [See Fig 4.34 & 4.35].

Consider this example,

Fig 4.33a

TAS 100
GS 100

TAS 100
GS 100

A ●——————————————————————————————————● B

|←————————————————— 100 nm —————————————————→|

The distance from A to B is 100 nm. If an aircraft with a TAS of 100 kt flies from A to B, then turns around and flies back to A, how long will it take if there is no wind? [for simplicity ignore climbs, descents and the turn around].

Time out is 100 nm @ 100 kt GS	= 1 hour
Time home is 100 nm @ 100 kt GS	= 1 hour
Total time out and back	= 2 hours [Pretty obvious]

Now, let's repeat the exercise with a 30 kt wind blowing from B towards A. Wouldn't you reckon that with a 30 headwind out and a 30 tailwind home, the wind effect should cancel out leaving a total flight time once again of 2 hours? Let's see what happens.

Fig 4.34

TAS 100
GS 70

30 kt wind

TAS 100
GS 130

A ●——————————————————————————————————● B
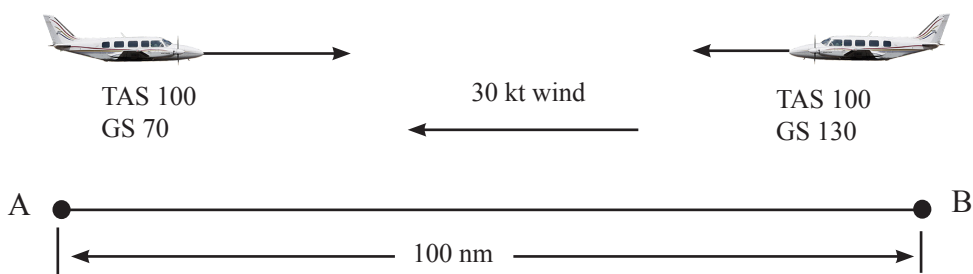
|←————————————————— 100 nm —————————————————→|

Time out is 100 nm @70 kt GS	= 85.7 min (86min)
Time home is 100 nm @ 130 kt	= 46.2 min (46min)
Total time out and back	= 131.9 min (132min)
	= 2 hours 12 min

Where did the extra 12 min come from?

The answer is in the time spent in the headwind and the tailwind. The aircraft suffered the 30 kt headwind for 86 min, but it enjoyed the 30 kt tail wind for only 46 min. The winds don't cancel out because the headwind was acting for a longer time.

What if the wind was blowing from the other direction?

Fig 4.35

TAS 100	30 kt wind	TAS 100
GS 130		GS 70

A •———————————————————————————————————• B

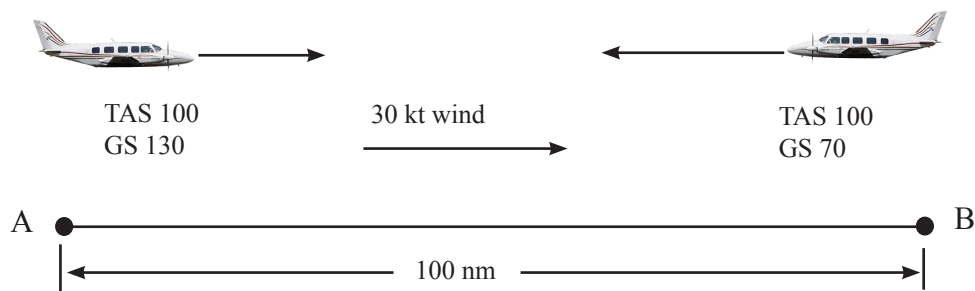|←————————————————— 100 nm —————————————————→|

Time out is 100 nm @130 kt GS   = 46.2 min (46min)
Time home is 100 nm @ 70 kt   = 85.7 min (86min)
Total time out and back   = 131.9 min   (132min
     = 2 hours 12 min

It doesn't matter whether the wind is a headwind or a tailwind, any wind at all will add to the time taken to complete the flight compared to the nil wind situation.

The PNR therefore, will always be at the greatest distance out in no wind. Any wind, head or tail, will reduce the distance to the PNR.

By the way, this will be true of any flight that returns to the starting point without landing. A typical navigation training flight that goes from A to B to C etc and back to A, will always take longer on a windy day than on a calm day no matter which direction the wind is coming from.

CALCULATING THE TIME TO THE PNR.

Consider the following example:

A charter aircraft cruises at a TAS of 185 kt, and has a fuel flow during cruise of 28 gph. The tailwind component on the flight planned track is 25 kt and start up is with 120 gal. If 3 gal is allowed for start-up and taxi, and 15 gal is allowed for the fixed reserve, find the time to the PNR [ignore climb and descent].

STEP ONE: Find the safe endurance.

Trip fuel available   = [120 - 3 - 15] ÷ 1.1
     = 92.7 gal
At 28 gph   = 198.6 min
Safe endurance   **= 199 min**

Fig 4.36

25 kt wind

TAS = 185 kt
GS out = 210 kt.

TAS = 185 kt
GS home = 160 kt

A

PNR

Safe endurance
on departure = 199 min
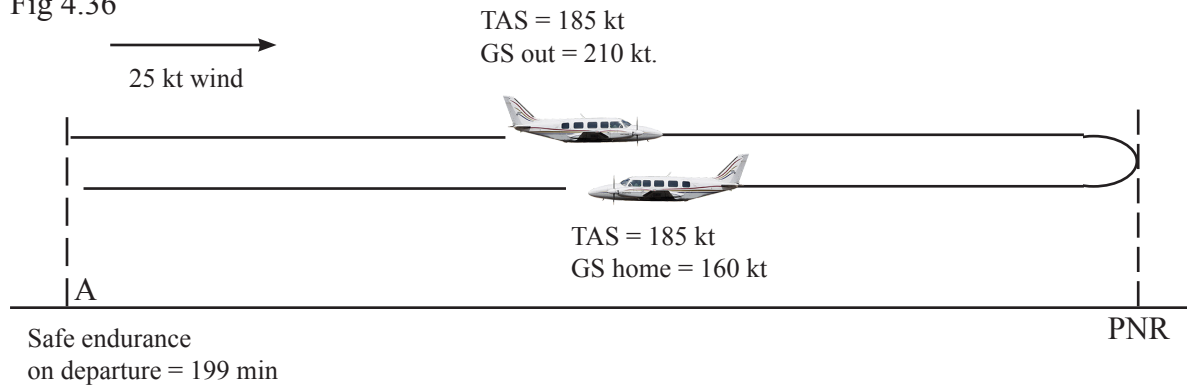
To calculate the time to the PNR you need to know:

1. Safe endurance
2. The GS home
3 . The TAS

The formula is:

Time to PNR $= \dfrac{\text{Safe endurance x GS home}}{\text{SUM OF THE GSs}}$ *(the wind was given as a component so use 2 x TAS)*

$= \dfrac{199 \text{ x } 160}{370}$

$=$ 86.1 min (86min)

If you fly out for more than 86 min you will not be able to return to A with all reserves intact.

DISTANCE TO THE PNR.

How far from A is the PNR?

For the 86 min spent flying out to the PNR you will be covering the ground at 210 kt. The distance to the PNR is

210 kt for 86.1 min   **= 301 nm.**

PROOF:

The 301 nm flight out to the PNR will take 86 min [from the formula above].
The 301 nm flight back to A will take 113 min [301 nm @ 160 kt].
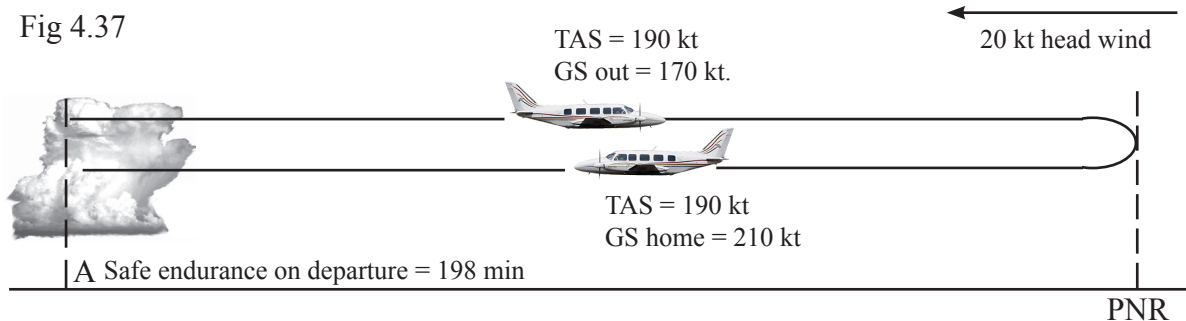*The flight out to the PNR and back will take 113 + 86 = 199 min.*
This agrees with the safe endurance in STEP ONE.

ANOTHER EXAMPLE

AIRCRAFT DATA AND COMPANY POLICY

NORMAL TAS	190 kt
ASYMMETRIC TAS	110 kt
NORMAL FUEL FLOW	120 l/hr
ASYMMETRIC FUEL FLOW	85 l/hr
FUEL TANK CAPACITY	680 l
FIXED RESERVE CALCULATED AT CRUISE RATE	
VARIABLE RESERVE OF 10% OF THE Trip fuel	
START UP AND TAXI ALLOWANCE	15 l

Find the distance to the PNR on a charter flight for the aircraft whose data is shown above, if start up is with full tanks, a 20 kt head win component exists at all levels, and the departure aerodrome requires 60 min holding fuel [For company policy on fuel reserves, see question data above].

Fig 4.37

TAS = 190 kt
GS out = 170 kt.

20 kt head wind

TAS = 190 kt
GS home = 210 kt

A Safe endurance on departure = 198 min

PNR

Step 1:

Find the safe endurance.

Trip fuel available at start up = [Total fuel - taxi - fixed reserve - holding] ÷ 1.1
= [680 - 15 - 90 - 120] ÷ 1.1
= 413.6 lts

@ 120 lts/hr = 206.8 min

Step 2:   **[Note the PNR calculation assumes normal ops]**

Find the time to the PNR
$$= \frac{\text{Safe Endurance x GS Home}}{2 \text{ x TAS } \textit{(the wind was given as a component)}}$$

$$\frac{206.8 \text{ x } 210}{380}$$

= 114.3 (114min)

Step 3:

Find the distance to the PNR = 114.3 min @ GS Out
= 114.3 min @ 170 kt
= 323.9 nm.

Distance to the PNR is 324 nm.

Revision exercises on ETP and PNR. [Answers on Page 134]

Aircraft data for use in Questions 1 to 11 of the following questions.
The data below relate to a charter flight in a light twin-engine aeroplane.

Cruise TAS normal operation [two engines operating]   160 kt.
Normal fuel consumption [two engines operating]   23 gallons/hr.
Asymmetric cruising TAS [one engine operating]   110 kt.
Asymmetric fuel consumption [one engine operating]   25 gallons/hr.
Fuel consumption for holding if required   17 gallons/hr.
Start-up and taxi allowance   3 gallons.
Fuel reserves are in accordance with the CAAP [Calculate fixed reserve at cruise rate].

Question No 1
You are planning a flight of 240 nm in the above aircraft. The flight planned track is 350°M and
the wind is from 350°M at 40kt. Find the distance and time to the ETP based on normal operation.
   [a]   The ETP is 90 nm and 45 minutes from the departure aerodrome
   [b]   The ETP is 150 nm and 45 minutes from the departure aerodrome
   [c]   The ETP is 90 nm and 27 minutes from the departure aerodrome
   [d]   The ETP is 150 nm and 75 minutes from the departure aerodrome

Question No 2
FTP is 325°M and the wind is from 270°T at 30kt. The variation is 10°E. Using the data given,
determine the distance to the PNR if the trip fuel available at take-off is 67 gallons.
   [a]   312 nm   [b]   228 nm   [c]   190 nm   [d]   160 nm

Question No 3
The distance A to B is 300 nm, the FPT is 125°M, wind is 330°T at 25 knots and variation is 12°E,
determine the distance and time required to fly from the ETP back to the departure aerodrome.
   [a]   The distance and time to return from the ETP is 128 nm and 56 mins
   [b]   The distance and time to return from the ETP is 128 nm and 36 mins
   [c]   The distance and time to return from the ETP is 178 nm and 56 mins
   [d]   The distance and time to return from the ETP is 56 nm and 178 mins.

Question No 4
FPT A to B is 025°M: Wind 190°T at 40kt: Variation 15°E. If the distance from Alpha to Bravo
is 300 nm, find the distance and time from the ETP to Bravo:
   [a]   The distance to Bravo is 136 nm and the time to Bravo is 56 min
   [b]   The distance to Bravo is 183 nm and the time to Bravo is 82 min
   [c]   The distance to Bravo is 122 nm and the time to Bravo is 39 min
   [d]   The distance to Bravo is 183 nm and the time to Bravo is 57 min

Question No 5
Find the trip fuel available for a charter flight if the usable fuel on board at start-up is 140gal.
   [a]   104 gal   [b]   109 gal
   [c]   120 gal   [d]   123 gal

Question No 6

Find the distance to the PNR for a flight that has 120 gallons on board at take-off if the FPT is 290°M, the forecast wind is 360° at 40 kt and the variation is 10°E.

    [a]   408 nm   [b]   403 nm

    [c]   375 nm   [d]   312 nm

Question No 7

FPT Alpha to Bravo is 220°M and distance is 180nm. If the wind is from 220°M at 15kt.. What is the distance and time from the asymmetric ETP back to Alpha?

    [a]   The distance back to Alpha is 78 nm and the time back to Alpha is 50 minutes

    [b]   The distance back to Alpha is 102 nm and the time back to Alpha is 64 minutes

    [c]   The distance back to Alpha is 78 nm and the time back to Alpha is 38 minutes

    [d]   The distance back to Alpha is 102 nm and the time back to Alpha is 49 minutes

Question No 8

During a charter flight from Alpha to Bravo, FPT 060°M. You overfly an on-track NDB 103nm from Alpha. You recalculate the fuel available as 95 gallons total usable fuel. The wind has been from 070°T at 10 knots. The variation is 10°E. The TAF for Bravo has no operational requirements for your planned arrival and the TAF for Alpha has a TEMPO requirement all day. The distance from Alpha to the PNR is closest to:

    [a]   282 nm   [b]   275 nm

    [c]   260 nm   [d]   242 nm

Question No 9

If the headwind component increases on the flight planned track

    [a]   Both the PNR and the ETP will move further from the departure aerodrome

    [b]   Both the PNR and the ETP will move closer to the departure aerodrome

    [c]   The PNR will move closer to and the ETP will move further from the departure aerodrome

    [d]   The PNR will move further from and the ETP will move closer to the departure aerodrome

Question No 10

You calculated the distance to the ETP and PNR during flight planning using a forecast tailwind of 30 knots. During cruise you discover that the actual tailwind is only 10 knots. How will this affect the actual position of the ETP and PNR compared to their original flight planned positions?

    [a]   Both the ETP and PNR will be further from the departure aerodrome

    [b]   Both the ETP and PNR will be closer to the departure aerodrome

    [c]   The ETP will be further from and the PNR will be closer to the departure aerodrome

    [d]   The ETP will be closer to and the PNR will be further from the departure aerodrome

Question No 11

The following data relates to a charter flight.

Total distance	300 nm, FPT is 185°M
TAS in cruise	150 kt.
Wind component from GAF	200/15 kt
Magnetic variation	15°E
Fuel flow during cruise	56 litres/hr.
Fixed reserve	45 minutes at cruise rate.
Start-up and taxi allowance	5 litres
Start-up is with minimum fuel required.	

Determine the time to the ETP and the distance to the PNR:

[a]   The time to the ETP is 73 min. and the distance to the PNR is 165 nm

[b]   The time to the ETP is 45 min. and the distance to the PNR is 130 nm

[c]   The time to the ETP is 70 min. and the distance to the PNR is 150 nm

[d]   The time to the ETP is 140 min. and the distance to the PNR is 51 nm

Question No 12

For this question, use the Echo data not the data given at the beginning of this exercise.
An Echo aircraft is to conduct a charter flight from Alpha to Bravo.

Distance from Alpha to Bravo	500 nm
Ground speed during cruise	170 kt
Cruise power	65%
TAF for Alpha has TEMPO conditions all day.	
TAF for Bravo has INTER conditions all day.	
Calculate holding at 20 gallons per hour.	
Usable fuel at start-up	145 gallons
Ignore any climbs and descents.	

The safe endurance that should be used to calculate the position of the PNR is closest to:

[a]   288 min

[b]   208 min

[c]   176 min

[d]   150 min

ANOTHER EXAMPLE OF PNR/ETP CALCULATIONS

You are planning a charter flight in the aircraft whose details are given below.

TAS 180kt	Cruise 50 litres per hour
Holding at rate 30 litres per hour	Fixed reserve 45 minutes at cruise rate
Variable reserve 10% of trip fuel	Taxi allowance 5 litres

Details of the planned flight	Distance A to B 244nm
Flight Planned Track 040°M	GPTW wind 36030KT
Magnetic variation 10°E	Holding required at B 30 minutes
Holding required at A 60 minutes	Fuel on board at start-up 190 litres

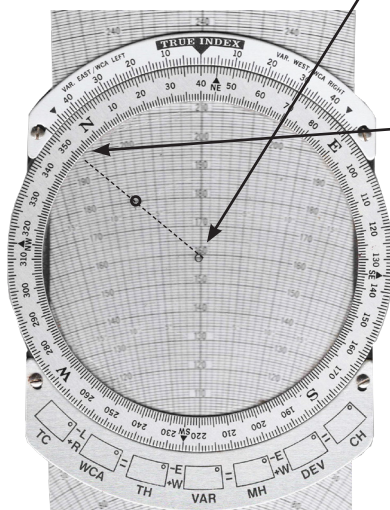**Find**

Distance from A to the PNR

Distance from the ETP to B

[Worked answer on opposite page]

ANSWER TO ANOTHER EXAMPLE OF PNR/ETP CALCULATIONS

The only difference in this presentation is that you are not given the wind as a headwind or tailwind component, you have to work the ground speeds out for yourself from the data given. The wind from a GPWT chart is always in degrees true. So you need to apply the 10E variation. The wind is from 000°T (350°M) at 30 kt and the flight planned track is 040°M. Find the ground speeds out and back from your flight computer.

Ground speed out is =159kt   Ground speed home is =198kt

Wind from 350°M

159kt

60 min holding   198kt   30 min holding

A ————————————————————————— B

Note that when you are calculating a PNR, the destination aerodrome (B), has nothing to do with it. As far as a PNR is concerned, the departure aerodrome is also your destination. In this case, you would have to allow for holding at A when you return from the PNR.

Trip fuel available for the PNR calculation
(Total fuel on board - fixed reserve - taxi - holding on return to A) ÷ 1.1
    (190 - 37.5 - 5 - 30) ÷ 1.1   = 106.8 litres

Safe endurance at 50 litres per hour
    106.8 ÷ 50 x 60   = 128.2 minutes

Time to PNR   = Safe endurance x GS home ÷ sum of the GSs
                = 128.2 x 198 ÷ 357
                = 71.1 minutes.

Distance to PNR   = 71.1 minutes at 159 knot
                = 188.4 nm.

Distance to ETP from A   = Total distance x GS home ÷ sum of the GSs.
                = 244nm x 198 ÷ 357 = 135.3
                = 135nm.

So distance from the ETP to B   = 244 -135
                = 109nm.

ANSWERS TO EXERCISES AND TESTS TOPIC 4

ANSWERS TO EXERCISE 4.1

No 1

Entry argument for Max rate climb on Page 14 of the supplement is density height, so find the density height.

```
  1500
  Altitude
                  Pressure Height
  QNH  1001           1860
                                    4500
  +11                              Density Height
  ISA Temperature    +22
                     ISA Deviation
  +33                 [+2640]
  OAT
```

Enter the table on Page 14 of the supplement at 5000 ft density height and 2950 kg

Max Rate of climb = 1500 ft/min.

No 2

Use the Density Height as the entry argument for Max rate climb table on Page 14 of the supplement.

```
  7000
  Altitude
                  Pressure Height
  QNH   1033          6400
                                    5560
  +2                               Density Height
  ISA Temperature    -7
                     ISA Deviation
  -5                  [-840
  OAT
```

Enter at Density Height 5000 and 2500 kg.

Max Rate of Climb = 2100 ft/min

No 3

Use the Density Height as the entry argument for Max rate climb table on Page 14 of the supplement.

```
  Zero
  Altitude
                  Pressure Height
  QNH  1010           +90
                                    2490
  +1                               Density Height
  ISA Temperature    +20.18
                     ISA Deviation
  +35                 +2400
  OAT
```

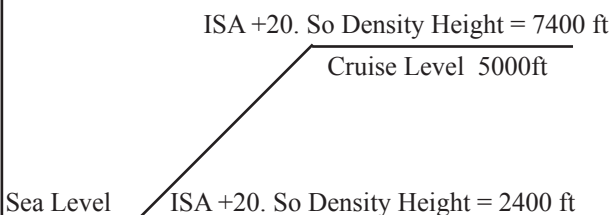Enter at Density Height 2500 by interpolating between zero and 5000 figures. And between 2950 and 2500 kg for weight.

[1600 + 1500 + 2250 + 2100] ÷ 4 = 1862.5

Max Rate of Climb = 1862.5 ft/min

ANSWERS TO EXERCISE 4.2

No 1

To find the time to climb you will need to know the average rate of climb and the height you climb through.

```
                    ISA +20. So Density Height = 7400 ft
                         Cruise Level  5000ft

Sea Level        ISA +20. So Density Height = 2400 ft
```

Since it is an ISA +20 day, you can add 20x120 = 2400 ft on to all pressure heights to obtain a density height. If no QNH is given, you are quite justified in assuming 1013 hPa. i.e. call all heights pressure heights.

The average rate of climb is found half way between 2400 and 7400 ft. So use the 5000 ft figures for the average.

Enter at 5000 ft for rate of climb of 1500 ft/min and TAS of 109 kt.

You will climb through 5000 ft at an average rate of 1500 ft/min so time to climb is 5000 ÷ 1500 = **3.3 min**

Distance to climb is 3.3 min at an average TAS of 109 kt = 6 nm.

Fuel used in climb is 3.3 min at 100% power. [See Page 16 of the supplement], 100% power gives a fuel flow of 63.4 gph. So fuel used is **3.5 gal**

No 2

Interpolate for weight between 2950 and 2500 kg
Half way between Sea Level and 10000 ft in ISA conditions is 5000 ft. Average rate of climb is [1500+2100]÷2=1800 ft/min. So time to climb is 10000 ft at 1800 ft/min = 5.5 min

Average TAS is [109+99] ÷ 2 = 104 kt and headwind is 25kt giving a ground speed of 79 kt. So distance to climb is 5.5 min at 79 kt = **7.24 nm**
Fuel used is 5.5 min at 63.4 gph = **5.8 gal**

No 3

Find the density height at Newman on this day.

```
  1724
  Altitude
                  Pressure Height
  QNH  1000           2114
                                    2594
  +11                              Density Height
  ISA Temperature    +4.228
                     ISA Deviation
  +15                 [+480]
  OAT
```

Interpolate between zero and 5000 ft on single engine climb table on Page 14 of the supplement.

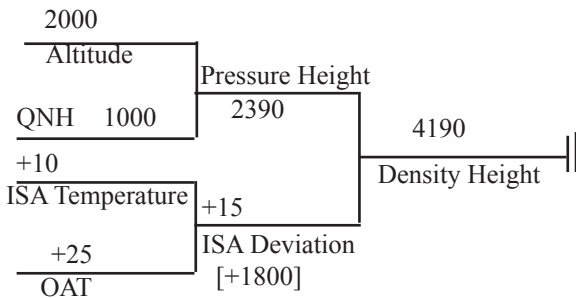Rate of climb at 2500 kg =[525 + 450]÷ 2 = 487.5 ft/min and TAS = [97+103]÷2 = 100 kt

Time to climb from 50 ft AGL to 500 ft AGL i.e. 450 ft is 450 ÷ 487.5 = .92 min

Distance to climb is .92 min at 100 kt [no wind]
= 1.53 nm

ANSWERS TO EXERCISE 4.3
No 1
To obtain the rate of climb from Page 14 of the supplement, find the density height.

```
    2000
    Altitude
                    Pressure Height
    QNH    1000         2390
                                    4190
    +10                         Density Height   ‖|
    ISA Temperature  +15
            +25         ISA Deviation
            OAT          [+1800]
```

Enter at 5000 ft and 2500 kg to obtain a rate of climb of 2100 ft/min and a TAS of 99 kt.

Climb gradient = 2100 ÷ 99 = 21.21% [2 engines]
Using the single engine chart = 4.37%

No 2
At 5000 pressure height, the ISA temperature is +5°C. Since the temperature is given as +25°C, it is an ISA+20 day. Density height = 7400 ft. So enter Maximum Rate of Climb chart by interpolating between 5000 and 10000 ft and 2950 and 2500 kg.

Rate of climb = 1737.5 ft/min and TAS = 108.25 kt

Climb gradient = 1737.5 ÷ 108.25 = 16.05%[2 engines]
On one engine from single engine chart = **2.49%**

No 3
A QNH of 1033 and a temperature of +5°C at sea level will produce a negative density height. Since the chart does not list negative values, you must use the zero figures. For 2000 kg and zero density height, rate of climb=2950 ft/min and TAS = 82 kt
Climb gradient = 2950 ÷ 82 =35.9% [2 engines]
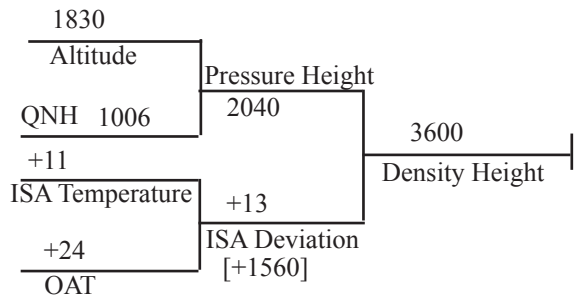From max climb table = **8.48% on one engine**

No 4
ISA +4, so density height is 2480 ft. Interpolate between zero and 5000 ft and 2000 and 2500 kg
Rate of climb = 2525 ft/min and Tas = 90.25 kt

Climb gradient two engines = 2525 ÷ 90.25 =**27.97%**
On 1 engine = **6.28%**

No 5
Find the density height.

```
    1830
    Altitude
                    Pressure Height
    QNH   1006          2040
                                    3600
    +11                         Density Height   ‖|
    ISA Temperature  +13
            +24         ISA Deviation
            OAT          [+1560]
```

Interpolate between zero and 5000 for density height and between 2500 and 2950 kg.
Rate of climb = 1862.5 ft/min and TAS = 100.25 kt
Gradient = 1862.5 ÷ 100.25 = **18.58 % [2 engines]**
From single engine climb table = **3.49% [1 engine]**

ANSWERS TO EXERCISE 4.4
No 1
From the Supplement Page 15.
Climb distance = 21.5 nm
Climb time = 8.5 min
Climb fuel = 6 gal

No 2

+15°C at 5000 ft is ISA + 10
from TAS table on Page 16 of the supplement.
5000 ft ISA   2500 kg 75% power = 192 kt
5000 ft ISA+20 2500 kg 75% power= 195 kt

So 5000 ft ISA +10 at 2500 kg 75% power = **193.5 kt.**

The answers to exercises 4.5 to 4.18 have been rounded to one decimal place.

EXERCISE 4.5

GROUND SPEED	TIME	DISTANCE
95	47	**74**
130	52	113
130	**36**	78
163	31	**84**
162	17	46
87	**34**	49
105	56	**98**
144	43	103

EXERCISE 4.6

Litres	Gallons	Kilograms
25	**7**	**18**
277	7.3	**199**
200	**53**	144
166	**44**	**120**
369	97	**264**
122	**32**	88

EXERCISE 4.7

RATE	35	**11.4**	11	**23**	23
QUANTITY	120	55	**32**	65	**36**
TIME	**206**	290	175	170	93

EXERCISE 4.8

FUEL REQUIRED AT START-UP		Trip fuel	
gallons	litres	gallons	litres
32.5	123.5	20.5	77.9
31.7	120.5	19.7	74.9
48.5	184.3	36.5	138.7
55.5	210.9	43.5	165.3
25.7	97.7	13.7	52.1

EXERCISE 4.9

FUEL REQUIRED AT START-UP		Trip fuel	
gallons	litres	gallons	litres
43.8	168.5	31.6	120.2
48.2	183.3	32.1	121.9
24.1	91.5	14.1	53.4
22.9	87	11	41.8
103.1	391.8	81.1	308

EXERCISE 4.10

Question No 1

Total distance	245 nm
Expected ground speed	110 kt
Estimated time interval	133.6 min
Trip fuel at 44 Lph	98 L
Fixed reserve	22 L
Start-up/taxi	6 L
Alternate [28 min @ 44 Lph]	20.5 L
Holding	none
Fuel required at start-up	**146.5 L**

Question No 2

Total distance	126 nm
Expected ground speed	155 kt
Estimated time interval	48.8 min
Trip fuel at 44 Lph	35.8. L
Fixed reserve	22 L
Start-up/taxi	6 L
Alternate [@ 44 Lph]	none
Holding	25 L
Fuel required at start-up	**88.8 L**

Question No 3

Total distance	89 nm
Expected ground speed	130 kt
Estimated time interval	41.1 min
Trip fuel at 44 Lph	30.1 L
Fixed reserve	22 L
Start-up/taxi	6 L
Alternate [42 min @ 44 Lph]	30.8
Holding	none
Fuel required at start-up	**88.9 L**

Question No 4

Total distance	223 nm
Expected ground speed	120 kt
Estimated time interval	111.5 min
Trip fuel at 44 Lph	81.8 L
Fixed reserve	22 L
Start-up/taxi	6 L
Alternate [@ 44 Lph]	none
Holding	12.5
Fuel required at start-up	**122.3 L**

PROGRESS TEST
TOPIC 4

Question No 1

[c] To convert litres to kilograms, multiply by the specific gravity. The specific gravity of AVGAS is .72
150 x .72 = 108 kg

Question No 2

	Total distance	180 nm
[b]	Ground speed	130 kt
	Time interval	83.1 min
	Trip fuel @ 40 Lph	55.4 L
	Fixed res 30 min @ 24 Lph	12 L
	Start-up/taxi allowance	10 L
	Fuel required at start-up	77.4 L

Question No 3

[c] 2 hr 12 min is 132 min

132 min @ 12.5 GPH	27.5 gal
Start-up/taxi	2 gal
Fuel used so far	29.5 gal
29.5 gal x 3.8	112 L

Question No 4

[a] Find the estimated time interval

Total distance	333 nm
Ground speed	124 kt
Time interval	161.1 min
Trip fuel @ 40 Lph	107.4 L
Fixed reserve	20 L
Start-up/taxi	5 L
Fuel required at start-up	132,4. L

Question No 5

[c] The reserves are already accounted for, so you can burn all of the 144 L.

144 L @ 33 Lph	261.8 min
261.8 min @ 127 kt	554.1 nm

Question No 6

[b]

Total distance	220 nm
Ground speed	135 kt
Estimated time interval	97.8 min
Trip fuel @ 9 GPH	14.7 gal
Fixed reserve	5 gal
Start-up/taxi	1 gal
Fuel required at start-up	20.7 gal

Question No 7

[c] No mention was made of a start-up/taxi allowance so ignore it. Find the total endurance at the beginning of the flight

Total endurance [205 L @ 43 Lph] 286 min
From 0425 to 0630 UTC is 125 min
Endurance at 0630 [286 - 125]   =161 min

Question No 8

[a] 2 hr 35 min is 155 min. In 155 min 87 L was used. Fuel consumption was 33.6 Lph

Question No 9

[c] Find the trip fuel available

Total fuel at start-up	115 L
Fixed res of 30 min @ 28 Lph	14 L
Start-up/taxi allowance	5L
Trip fuel available	96 L
Cruise endurance @ 28 Lph	205.7 min
Distance covered at 95 kt	325.7 nm

Question No 10 [c]

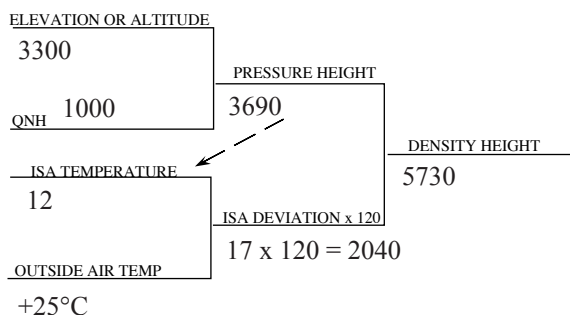|	
Total distance	155 nm
Ground speed	103 kt
Estimated time interval	90.3 min
Trip fuel @ 11.5 GPH	17.3 gal
Fixed res 30 min @ 8 GPH	4 gal
Start-up/taxi	none
Holding 30 min @ 8 GPH	4 gal
Fuel required at start-up	25.3 gal

Question No 11

[d]

Go to page 14 of the supplement. In the maximum rate of climb tables consider the figures listed under 2950kg gross weight.

At 5000ft the rate of climb to be expected is 1500 feet per minute.

Question No 12

[c]

ELEVATION OR ALTITUDE
3300

PRESSURE HEIGHT
3690

QNH   1000

ISA TEMPERATURE
12

DENSITY HEIGHT
5730

ISA DEVIATION x 120
17 x 120 = 2040

OUTSIDE AIR TEMP
+25°C

EXERCISE 4.11

Trip fuel	FUEL AT START-UP		
80 gal x 1.1 + 15 + 3	=	106 gal
25 gal x 1.1 + 15 + 3	=	45.5 gal
150 gal x 1.1 + 15 + 3	=	183 gal
95 gal x 1.1 + 15 + 3	=	12.5 gal
107 gal x 1.1 + 15 + 3	=	135.7 gal

EXERCISE 4.12

	FUEL AT START-UP		Trip fuel AVAILABLE
1	[150 gal -15-3] ÷ 1.1	=	120 gal
2	[100 gal - 15 - 3] ÷ 1.1	=	74.5 gal
3	[95 gal - 15 - 3]÷ 1.1	=	70 gal

EXERCISE 4.13

	TRIP FUEL		START UP
1	84 gal x 1.1 +15+3	=	**110.4 gal**
	228.5 kg x 1.1+41+8	=	**300.4 kg**
2	200 kg x 1.1 +41+8	=	**269 kg**
	73.5 gal x 1.1+15+3	=	**98.9 gal**
3	[120 gal - 15 - 3] ÷ 1.1	=	**92.7 gal**
	[**326.4 kg** - 41 - 8] ÷ 1.1	=	**252.1 kg**
4	[300 kg - 41 - 8] ÷ 1.1	=	**228.2 kg**
	[**110.3 gal** - 15 - 3] ÷ 1.1	=	**83.9gal**
5	120 kg x 1.1 +41+8	=	**180.9 kg**
	44.1 gal x 1.1 +15+3	=	**66.5 gal**

EXERCISE 4.14

155 min @ 28 gph = 73   30 min @ 17.2 gph = 8.6
Min fuel = 73 x 1.1 + 15 + 8.6 + 3 = **106.9 gal**
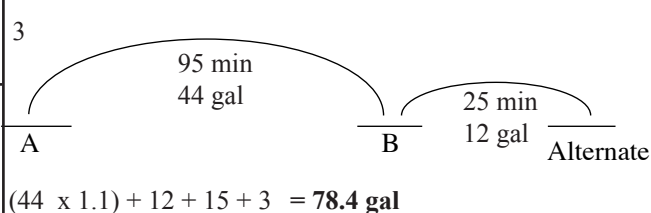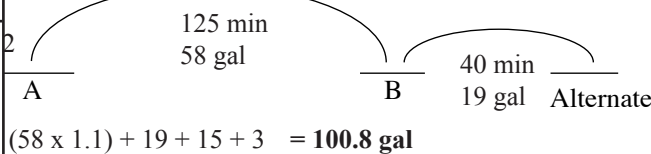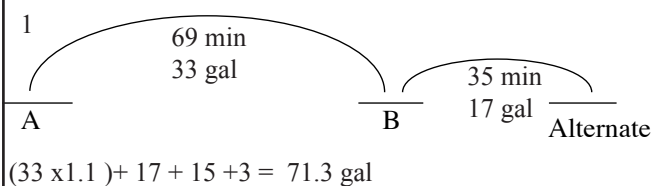
204 min @ 28 gph = 96   60 min @ 17.2 gph = 17.2
Min fuel = 96 x 1.1 + 15 + 17.2 + 3   **= 140.8 gal**

97 min @ 28 gph = 46 gal 45 min @ 17.2 gph = 12.9
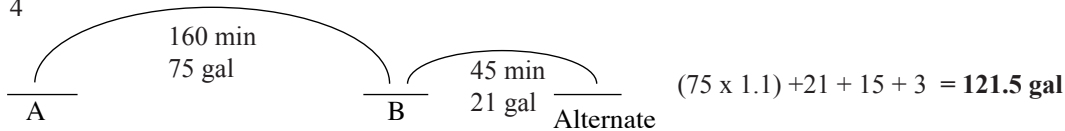Min fuel = 46 x 1.1 + 15 + 12.9 +3   **= 8.5 gal**

135 min @ 28 gph = 63 gal 30 min @ 17.2 gph = 8.6
Min fuel = 63 x 1.1 + 15 + 8.6 + 3   **= 95.9 gal**

84 min @ 28 gph = 40 gal 60 min @ 17.2 gph = 17.2
Min fuel = 40 x 1.1 + 15 + 17.2 +3   **= 79.2 gal**

EXERCISE 4.15

1
69 min
33 gal

35 min
17 gal

A   B   Alternate

(33 x1.1)+ 17 + 15 +3 = 71.3 gal

2
125 min
58 gal

40 min
19 gal

A   B   Alternate

(58 x 1.1) + 19 + 15 + 3   = **100.8 gal**

3
95 min
44 gal

25 min
12 gal

A   B   Alternate

(44 x 1.1) + 12 + 15 + 3   = **78.4 gal**

4

160 min
75 gal

A

45 min
21 gal   Alternate

B

$(75 \times 1.1) + 21 + 15 + 3$ = **121.5 gal**

ANSWERS TO EXERCISE 4.16

ISA CONDITIONS	POWER	TAS	WIND	G/ SPEED	F/ FLOW	ANMPG	GNMPG
2500 kg/ 10000 ft	65%	185	------	185	28 gph	6.61	6.61
2950 kg/15000 ft	75%	205	-30	175	32.6 gph	6.29	5.37
2725 kg/12500 ft	55%	170.75	+25	195.75	23.6 gph	7.23	8.29
2500 kg/7500 ft	65%	181.5	-10	171.5	28 gph	6.48	6.12

ANSWERS TO EXERCISE 4.17
No 1
Find the TAS. 10000 ISA 2500 kg 65%=185 kt [nil wind]
Trip fuel = Distance x Fuel Flow ÷ Ground Speed
= 285 x 28 ÷ 185 = 43.1 gal
Min fuel = 43.1x 1.1 +15 +3 = **65.4 gal**
No 2
Find the TAS 15000 ISA +20 2725kg 55% =175.5 kt
Ground Speed = 175.5 - 25 = 150.5 kt
Trip fuel = Distance x Fuel Flow ÷ Ground Speed
= 358 x 23.6 ÷ 150.5 = 56.1 gal
Min fuel = 56.1 x 1.1 + 15 + 3 = **79.7 gal**
No 3
Find the TAS 5000 ISA -10 75% 2950 kg = 187
Ground Speed = 187 + 15 = 202 kt
Trip fuel = Distance x Fuel Flow ÷ Ground Speed
= 547 x 32.6 ÷ 202 = 88.3 gal
Min fuel = 88.3 x 1.1 + 15 + 3 = **115.1 gal**
No 4
17500 [ISA +10 day] 2250 kg
Investigate best ground nautical miles per gallon.

POWER	TAS	WIND	G/S	F/FLOW	MPG
55%	182.25	-30	152.25	23.6	6.45
45%	154.87	-30	124.87	20.4	6.12

So use 55% power for best GNMPG.
Trip fuel = Total Distance ÷ GNMPG
= 766 ÷ 6.45 = 118.7
Min fuel = 118.7 x 1.1 + 15 + 3 **= 148.6 gal**

ANSWERS TO EXERCISE 4.18
No 1
Find how much of the 120 gal on board at start up is available as trip fuel.
[120 - 15 - 3]÷1.1 = 92.7 gal
Less transit fuel = 42 gal
Available for search = 50.7 gal
Burn 50.7 gal at 17.2 gph = 177 min.

No 2
Fuel required for the search =90 min at 17.2 gph
= 25.8 gal
Transit fuel = 35 gal
Trip fuel required = 60.8 gal
Min fuel required = 60.8 x 1.1+ 15 + 3
= **84.9 gal**

No 3
Minimum fuel req'd for the flight 53 x 1.1 + 15 + 3
= 76.3 gal
Actual fuel available at start up = 100 gal
Margin fuel available for holding = 23.7 gal
This margin can be burnt at the holding rate of 17.2 gph
Maximum holding time = **82.7 min**

No 4
Find how much of the 144 gal is available as trip fuel
Trip fuel available = [144 - 15 - 3] ÷ 1.1 = 114.5 gal
Less transit fuel to and from the search area= 67 gal
Fuel available for holding = 47.5 gal
Burn 47.5 gal @ 17.2 gph = **165.7 min**

No 5
Fuel required for the search = 2 hours @ 17.2 gph
= 34.4 gal
Plus transit fuel = 18 gal
Total trip fuel required = 52.4 gal
Min fuel req'd at start up = 52.4 x 1.1 + 15 + 3 gal
= **75.6 gal**

No 6
Minimum fuel req'd for the flight = 66 x 1.1 + 15 +3
= 90.6 gal
Actual fuel available at start up = 102 gal
Margin fuel available for holding = 11.4 gal
Burn 11.4 gal @ 17.2 gph = **39.8 min**

No 7
Minimum fuel required to proceed to the alternate
= 26 + fixed reserve of 15 gal [no taxi fuel of course]
= 41 gal
Actual fuel available on arrival = 50 gal
Margin fuel available for holding = 9 gal
Burn 9 gal @ 17.2 gph = 31.4 min
Latest time for diversion to the alternate
= 0412 + 31.4
= 0**443**

ANSWERS TO ETP/PNR REVISION

Question No 1   Answer [d]

160 + 40 = 200 ◢ ◣ 160 - 40 = 120

The wind is a direct headwind 40 kt ⇦

240 nm

Distance to ETP   = 240 x 200 ÷ 320
                   = 150 nm
Time to ETP   = 150 nm @ 120 kt = **75 mins.**

Question No 2   Answer [b]

GS home 170 ◢ ◣ GS out 145

FPT 325°M: Wind 260°M @ 30kt: TAS 160 ⇦

Trip fuel = 67 gals @ 23 gph = 174.8 mins.
Time to PNR = 175 x 170 ÷ 315 = 94.3 mins.
Distance to PNR = 94.3 min @ 145 kt = **227.9 nm.**

Question No 3   Answer [a]

GS home 136 ◢ ◣ GS out 184

⇨ FPT 125: Wind 318/25: TAS 160

300 nm

Distance to ETP   = 300 x 136 ÷ 320
                   = 127.5 nm from A
Time back to A
from ETP   = 127.5 nm @ 136 kt = **56.25**

Question No 4   Answer [d]

GS home 124 ◢ ◣ GS out 194

⇨ FPT 025°M: Wind 175° at 40kt: TAS 160

300 nm

Distance to ETP   = 300 x 124 ÷ 318
                   = 117 nm
Distance to Bravo = 300 - 117 = 183 nm.
Time to Bravo   183 nm @ 194 kt = **56.6 min.**

Question No 5   Answer [b]

Trip fuel = [140 - 3 - 17.25] ÷ 1.1 = **109 gal.**

Question No 6   Answer [d]

GS out   = 136 from flight computer
GS home   = 176 from flight computer

176 ◢ ◣ 136

350M @ 40 ⇦

—290°M—

Distance to PNR = 307nm

Trip fuel = [120 - 17.25] ÷ 1.1 = 93.493.4 gal.
@ 23 gph = 243.7 min.
Time to PNR = 243.7 x 176 ÷ 312 = 137.5 mins.
Distance to PNR @ 136 kt = **312 nm.**

Question No 7   Answer [a]

110 + 15 = 125 ◢ ◣ 110 - 15 = 95

15 kt ⇦

180 nm

Distance to SE ETP = 180 x 125 ÷ 220
                    = 102.2nm
Time back to A   = 102.2 nm @ 125 kt = **49 mins.**

Question No 8   Answer [d]

The wind is an exact headwind along the track.
Your ground speed has been 160 -10 = 150 kt
Your fuel flow has been   23 gph
So GNMPG has been 150 ÷ 23   = 6.52 mpg

Alpha to the NDB fuel burnt is 103 ÷ 6.52 = 15.8 gal
So fuel on board over Alpha is 95 + 15.8 = 110.8 gal.
Trip fuel av'ble [Don't forget the TEMPO requirement
at Alpha. When you calculate a PNR, your departure
point is your destination. So you will have to com-
ply with any requirements that apply to the departure
aerodrome. In this case you need 60 minute holding
i.e. 17 gallons].
= [110.8 - 17.25 - 17] ÷ 1.1   = 69.6 gal.
Safe Endurance = 69.6 gal @ 23 gph   = 182 mins.
Ground speed out   = 150 kt.
Ground speed home   = 170 kt.
Time to PNR = 182 x 170 ÷ 320   = 97 min.
Distance to PNR = 97 min @ 150 kt.   = **242 nm.**


Question No 9   Answer [c]

The ETP always moves upwind from half way and the
stronger the wind, the further upwind it moves. So an
increase in headwind component will cause the ETP
to move towards the destination end of the track, i.e.
further away. The PNR is always the greatest distance
out in nil wind conditions, any wind, head or tail, will
move the PNR closer to base.

Question No 10   Answer [a]

The ETP moves up wind from half way. Based on a tail wind of 30 knots, the calculated position of the ETP would therefore be closer to the departure aerodrome than half way. If the actual tailwind was less than expected the ETP would be closer to half way than the calculated position. i.e. further from the departure aerodrome. If the wind component reduced the PNR would be further away since it is always furtherest out in no wind.

Question No 11   Answer [a]

The wind is an exact headwind (185°M)

150 - 15 = 165 ◣   ◢ 150 + 15 = 135

15 kt   ⇦

└─────────300 nm─────────┘
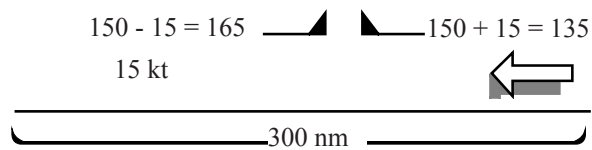
Distance to ETP   = 300 x 165 ÷ 300
                  = 165 nm
Time to ETP   = 165 nm @ 135 kt = 73.3 mins.

Trip fuel   = 300 x 56 ÷ 135
            = 124.4 litres.
Safe endurance = 124.4 litres @ 56 lph = 133.3 min.
Time to PNR   = 133.3 x 165 ÷ 300
              = 73.3 minutes.
Distance to PNR   = 73.3 mins @ 135 knots
                  = **164.9 nm.**

Question No 12   Answer [b]

If you fly to the PNR and back to Alpha, you will need the 60 minutes holding when you arrive at Alpha due to the TEMPO requirement. Therefore trip fuel available for the PNR calculation is:

[Total fuel - taxi - fixed res. - 60 min holding] ÷ 1.1
[145 - 3 - 15 - 20] ÷ 1.1   = 97.3 gallons.
Safe endurance   = 97.3 gallons @ 28 gph
                     = **209 minutes.**

STRUCTURAL WEIGHT LIMITATIONS

Having established the minimum fuel requirements for a flight, the operator will often need to consider the maximum payload that can be carried, especially in commercial operations. One of the factors that may control the maximum payload possible is the limitations on aircraft weight imposed by the manufacturer. Because these limitations consider the stresses that can be tolerated by the aircraft structure, they are called structural limitations.

> The structural **take-off weight** limitation
> The structural **landing weight** limitation
> The **zero fuel weight** structural limitation

The structural take-off weight limitation is imposed to prevent excessive loads on under-carriage components during the take-off run. It considers such things as side loads imposed by cross winds and the loads imposed by rough surfaces.

The structural landing weight limitation Many light aircraft manufacturers simply publish one structural weight limitation which applies to all flight situations. For example the Cessna 172 RG usually has a maximum weight limitation of 2650 lbs [1203 kg]. This is the maximum weight for take-off or landing. However some larger aircraft may have a different weight limit for landing which, because it considers the possibility of a heavier than normal landing, may be lower than the take-off weight limitation. It is imposed to prevent excessive loads on the undercarriage at touch-down and during the landing roll.

The zero fuel weight structural limitation is imposed on many larger aircraft to prevent excessive loads on the airframe during flight.

Compare the aircraft in the illustration in the figure at right with the plank below. Since each wing contributes equally to total lift in normal flight, and the total weight of the aircraft acts through the centre of gravity which is located somewhere in the aircraft's fuselage, bending loads are imposed on the aircraft structure especially at the wing roots.

This arrangement of forces is similar to the situation depicted in Fig 5.1 at right. The plank is suspended by two ropes and a heavy weight is suspended from the centre of the plank.

The heavy weight represents items such as passengers and cargo which are normally placed in the fuselage.

Fig 5.1