Awesome ATPL Formulas

Performance

(Logo iCadet.com)

Content

1. Climb Gradient

Description: The climb gradient is defined as the ratio of the increase of altitude to horizontal air distance expressed as a percentage.

Formula:

$$Climb\ Gradient\ = \left(\frac{Thrust\ -\ Drag}{Weight}\right)\ x\ 100$$

$$Climb\ Gradient\ = (\frac{Thrust}{Weight})\ -\ (\frac{1}{L/D\ Ratio})\ x\ 100$$

Explanatory notes:

- Insert Thrust in Newtons (N)
- Insert Weight in Newtons (N)
- Drag is equal Mass / Lift to Drag Ratio
- Weight is equal Mass x 10 (assume g = 10 m/s2)
- You will get result in percentage (%)

Example:

Consider an airplane with four engines. One engine failed. Calculate the climb gradient with the given values:

Mass: 358 000 Kg
Drag: 455 000 N
Thrust: 245 000 N (each engine)

(Consider: Acceleration of gravity = 10 m/s2)

---

1. First, we have to calculate the total thrust. One engine is failed, so we have to consider only three engines in the calculation:

$$Thrust \ = \ Number\ of\ working\ engines\ x\ Thrust\ on\ each\ engine\ (N)$$

$$Thrust \ = \ 3\ x\ 245\ 000 \ = \ 735\ 000\ N$$

2. Then we have to calculate Weight from given Mass:

$$Weight \ = \ Mass\ (Kg)\ x\ Acceleration\ of\ gravity\ (m/s2)$$

$$Weight \ = \ 358\ 000\ x\ 10 \ = \ 3\ 580\ 000\ N$$

3. And finally, we substitute the numbers into the equation:

$$Climb\ Gradient \ = (\frac{Thrust \ - \ Drag}{Weight})x\ 100$$

$$Climb\ Gradient \ = (\frac{735\ 000 - 455\ 000}{3\ 580\ 000})x\ 100 \ = \ 7.8\%$$

2. Rate of Climb

Description: Rate of climb is an aircraft vertical speed = positive rate of altitude change with respect to time. It's usually expressed in feet per minutes.

Formula:

$$Rate\ of\ Climb\ =\ Climb\ Gradient\ x\ TAS$$

Explanatory notes:

- Insert Climb Gradient in percentage (%)
- Insert True Airspeed (TAS) in Knots (kts)
- You will get result in feet per minute (ft/min.)
- Some ATPL questions provide Ground Speed instead of True Airspeed. If wind is provided, True Airspeed has to be calculated. If no wind is provided, then assume wind is still and TAS = GS.

Example:

What rate of climb will be achieved with a climb gradient of 3.3% and a groundspeed of 100 kts?

---

1. There is no True Airspeed provided in the question, so assume still wind:

$$TAS\ =\ GS\ =\ 100\ kts$$

2. Substitute the numbers into the equation:

$$Rate\ of\ Climb\ =\ Climb\ Gradient\ x\ TAS$$

$$Rate\ of\ Climb\ =\ 3.3\ x\ 100\ =\ 330\ ft/min.$$

3. Climb Distance

Description: Climb distance is a required distance to reach a given height. It can be either ground distance or still air distance.

Formula:

$$Ground\ Distance\ =\ Still\ Air\ Distance\ x\ (\frac{GS}{TAS})$$

$$TAS\ =\ \frac{Distance}{Time}$$

$$Still\ Air\ Distance\ =\ (\frac{Height\ difference}{Climb\ Gradient})\ x\ 100$$

Explanatory notes:

- Insert Height difference in feet (ft)
- Insert Climb Gradient in percentage (%)
- Insert True Airspeed (TAS) or Ground Speed (GS) in Knots (kts)
- To calculate TAS, insert Distance in Air Nautical Miles (NAM) and Time in Hours (hr)
- You will get Ground Distance in Nautical Miles (NM)
- You will get Still Air Distance in Air Nautical Miles (NAM)
- In the ATPL exams, Still Air Distance is usually find in the given performance chart. Then, Ground Distance is calculated using the first two formulas above.

Example:

Calculate ground distance in nautical miles (NM) if time to travel 18 NAM of distance is 9 minutes. Average headwind component is 20 kts.

---

1. Time is provided in minutes, we need hours for our calculation:

$$Time\ in\ hours\ =\ \frac{Time\ in\ minutes}{60}\ =\ \frac{9}{60}\ =\ 0.15\ hr$$

2. There is no True Airspeed provided in the question, so first we have to calculate TAS:

$$TAS\ =\ \frac{Distance}{Time}\ =\ \frac{18}{0.15}\ =\ 120\ kts$$

3. Now we have to calculate Ground Speed. We know the average headwind component is 20 kts:

$$Ground\ Speed\ =\ TAS\ -\ Headwind\ =\ 120\ -\ 20\ =\ 100\ kts$$

4. Substitute the numbers into the equation:

$$Ground\ Distance\ =\ Still\ Air\ Distance\ x\ (\frac{GS}{TAS})$$

$$Ground\ Distance\ =\ 18\ x\ (\frac{100}{120})\ =\ 15\ NM$$

Performance Cheat Sheet

1. Climb Gradient

$$Climb\ Gradient\ = \left(\frac{Thrust\ -\ Drag}{Weight}\right)\ x\ 100$$

$$Climb\ Gradient\ = (\frac{Thrust}{Weight})\ -\ (\frac{1}{L/D\ Ratio})\ x\ 100$$

2. Rate of Climb

$$Rate\ of\ Climb\ =\ Climb\ Gradient\ x\ TAS$$

3. Climb Distance

$$Ground\ Distance\ =\ Still\ Air\ Distance\ x\ (\frac{GS}{TAS})$$

$$TAS\ =\ \frac{Distance}{Time}$$

$$Still\ Air\ Distance\ =\ (\frac{Height\ difference}{Climb\ Gradient})\ x\ 100$$