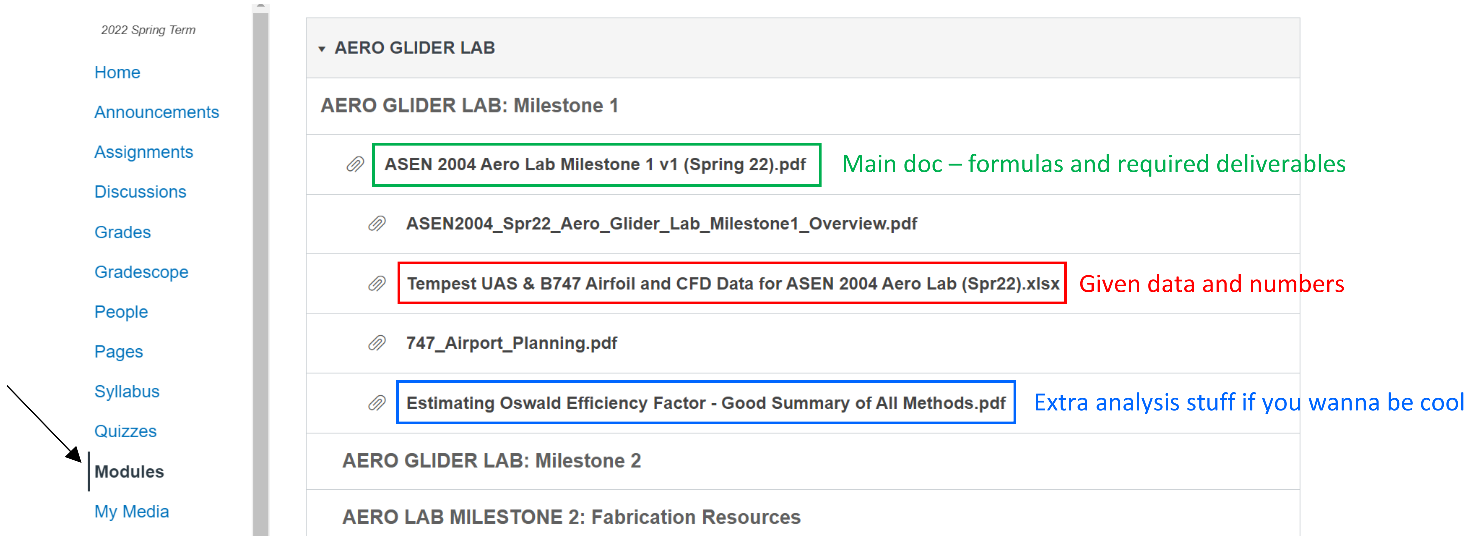

2022 Spring Term

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AERO GLIDER LAB

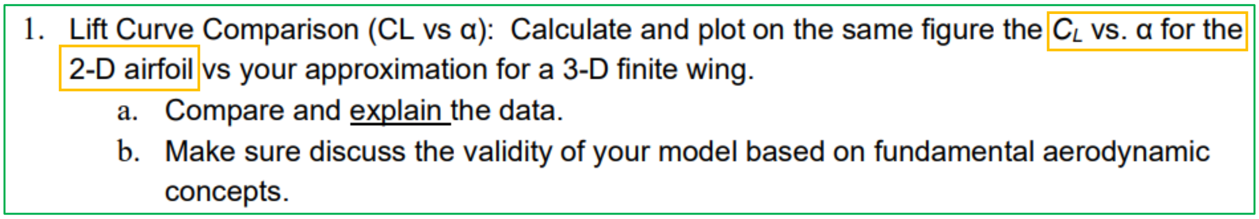
AERO GLIDER LAB: Milestone 1

- ASEN 2004 Aero Lab Milestone 1 v1 (Spring 22).pdf — Main doc – formulas and required deliverables
- ASEN2004_Spr22_Aero_Glider_Lab_Milestone1_Overview.pdf
- Tempest UAS & B747 Airfoil and CFD Data for ASEN 2004 Aero Lab (Spr22).xlsx — Given data and numbers
- 747_Airport_Planning.pdf
- Estimating Oswald Efficiency Factor - Good Summary of All Methods.pdf — Extra analysis stuff if you wanna be cool

AERO GLIDER LAB: Milestone 2

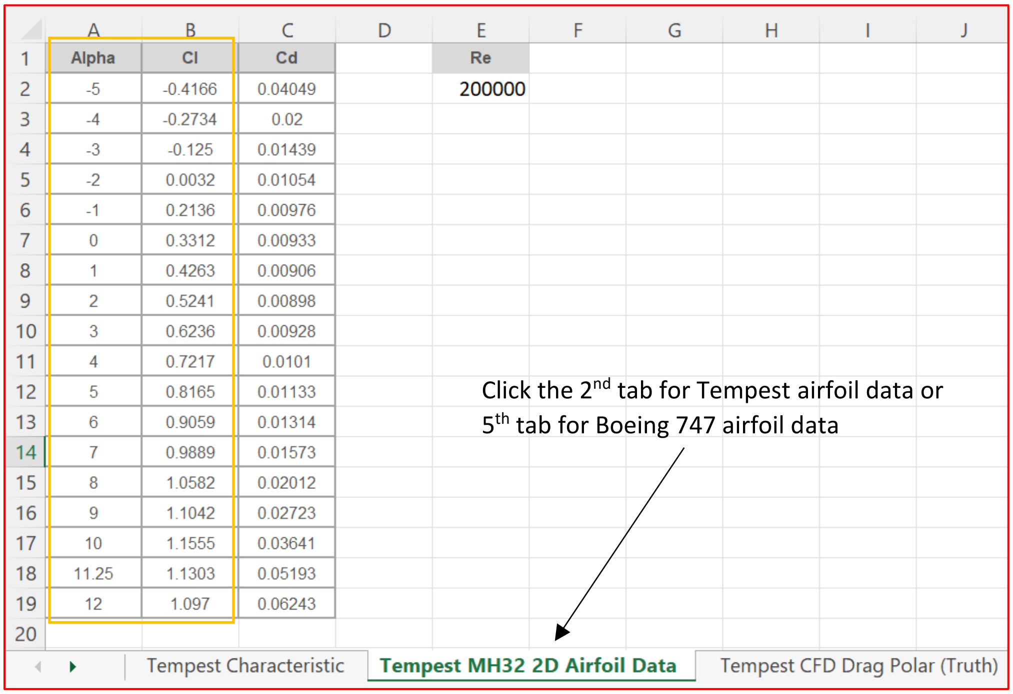
AERO LAB MILESTONE 2: Fabrication Resources

Step 1A (Page 8 of main doc):



1. Lift Curve Comparison (CL vs α): Calculate and plot on the same figure the C_L vs. α for the 2-D airfoil vs your approximation for a 3-D finite wing.
    a. Compare and explain the data.
    b. Make sure discuss the validity of your model based on fundamental aerodynamic concepts.

Download and open Excel spreadsheet of provided data

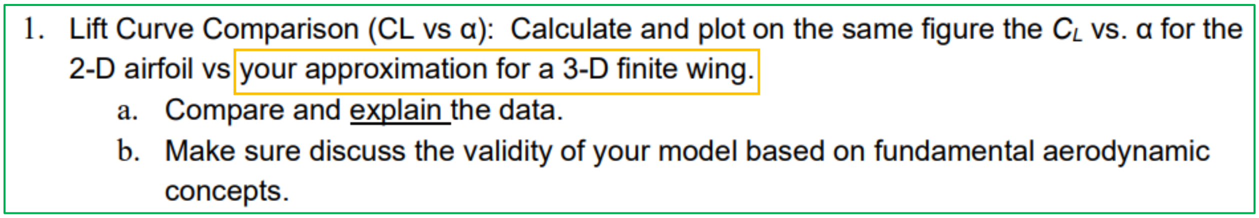


Alpha	Cl	Cd		Re
-5	-0.4166	0.04049		200000
-4	-0.2734	0.02		
-3	-0.125	0.01439		
-2	0.0032	0.01054		
-1	0.2136	0.00976		
0	0.3312	0.00933		
1	0.4263	0.00906		
2	0.5241	0.00898		
3	0.6236	0.00928		
4	0.7217	0.0101		
5	0.8165	0.01133		
6	0.9059	0.01314		
7	0.9889	0.01573		
8	1.0582	0.02012		
9	1.1042	0.02723		
10	1.1555	0.03641		
11.25	1.1303	0.05193		
12	1.097	0.06243		

Click the 2nd tab for Tempest airfoil data or 5th tab for Boeing 747 airfoil data

Plot α values on x-axis and C_l values on y-axis. This gives the plot for your 2D airfoil.

Step 1B (Page 8 of main doc):



1. Lift Curve Comparison (CL vs α): Calculate and plot on the same figure the C_L vs. α for the 2-D airfoil vs your approximation for a 3-D finite wing.
    a. Compare and explain the data.
    b. Make sure discuss the validity of your model based on fundamental aerodynamic concepts.

Page 4 of main doc:

$$C_L = a \cdot (\alpha - \alpha_{L=0}) \qquad (2)$$

C_L is ultimately what you want… break down quantities on right hand side until they are known.

What is a?

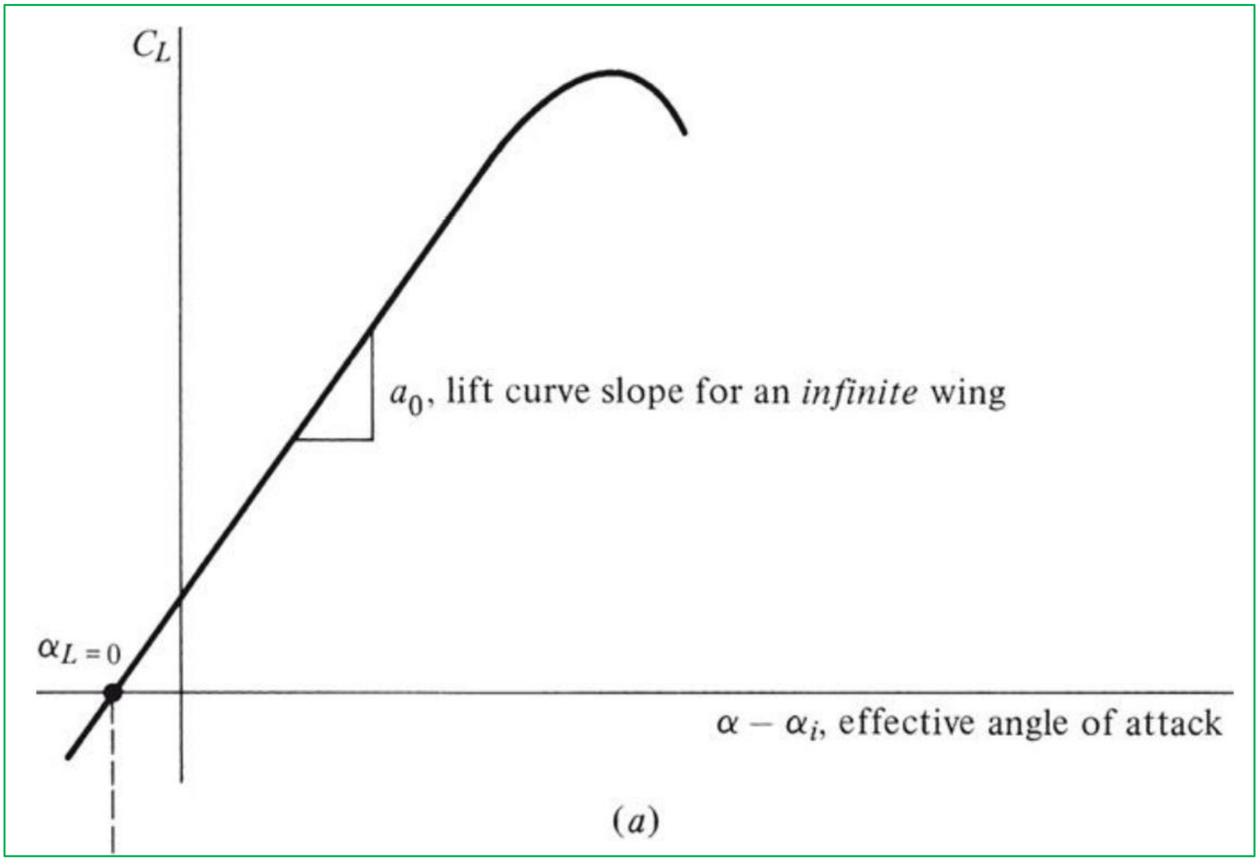
$$C_L = \boxed{a} \cdot (\alpha - \alpha_{L=0}) \qquad (2)$$

a is defined from Equation 1 in main doc:

$$a = \frac{dC_L}{d\alpha} = \frac{\boxed{a_o}}{1+\frac{57.3\cdot\boxed{a_o}}{\pi\cdot e\cdot AR}} \qquad (1)$$

What is a_0?

Figure 3 in main doc for reference:



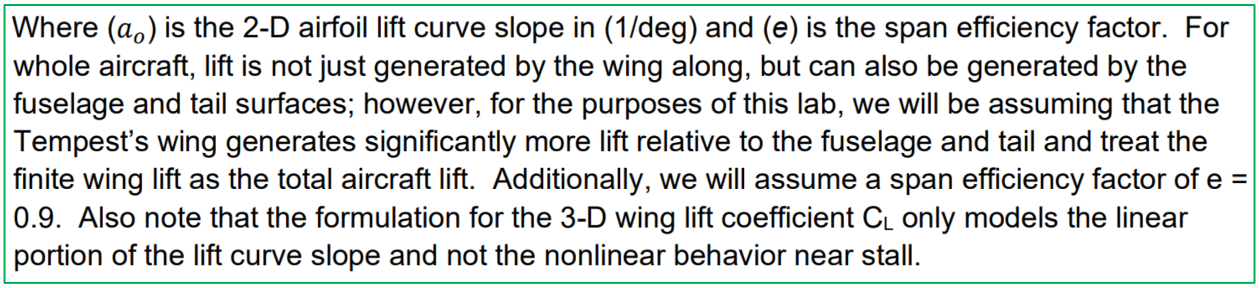
a_0 is defined to be the linear slope of the given 2D data you just plotted in *Step 1A*

1. From what you just plotted, determine what region (i.e. what data points, or what "indices") can most accurately be represented as linear
2. On that region, do one of the following… you know how to do this… (from 2012 ofc)
    - Least squares fit
    - Polyfit (yes, you're actually allowed to use this in this class because easier = good!)
    - Some other linear interpolation method… they're really all the same

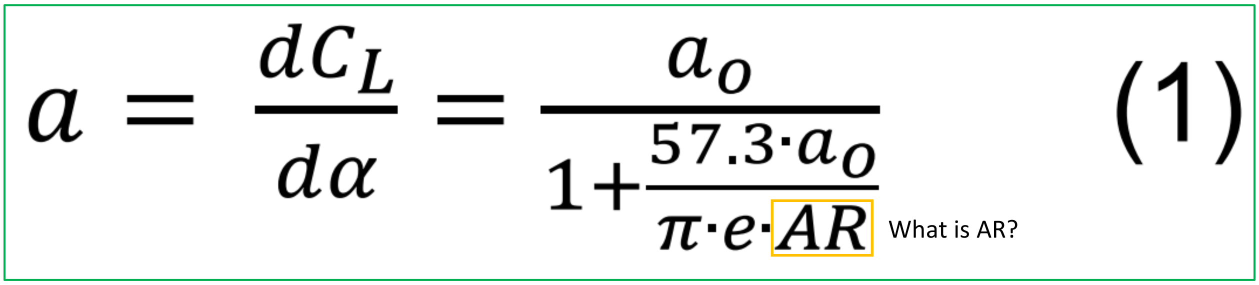
$$a = \frac{dC_L}{d\alpha} = \frac{a_o}{1+\frac{57.3\cdot a_o}{\pi\cdot\boxed{e}\cdot AR}} \qquad (1)$$

What is e?

Paragraph on page 4 of main doc: assume e = 0.9



Where (a_o) is the 2-D airfoil lift curve slope in (1/deg) and (*e*) is the span efficiency factor. For whole aircraft, lift is not just generated by the wing along, but can also be generated by the fuselage and tail surfaces; however, for the purposes of this lab, we will be assuming that the Tempest's wing generates significantly more lift relative to the fuselage and tail and treat the finite wing lift as the total aircraft lift. Additionally, we will assume a span efficiency factor of e = 0.9. Also note that the formulation for the 3-D wing lift coefficient C_L only models the linear portion of the lift curve slope and not the nonlinear behavior near stall.



$$a = \frac{dC_L}{d\alpha} = \frac{a_o}{1+\frac{57.3 \cdot a_o}{\pi \cdot e \cdot \boxed{AR}}} \qquad (1)$$

What is AR?

Excel spreadsheet with provided data

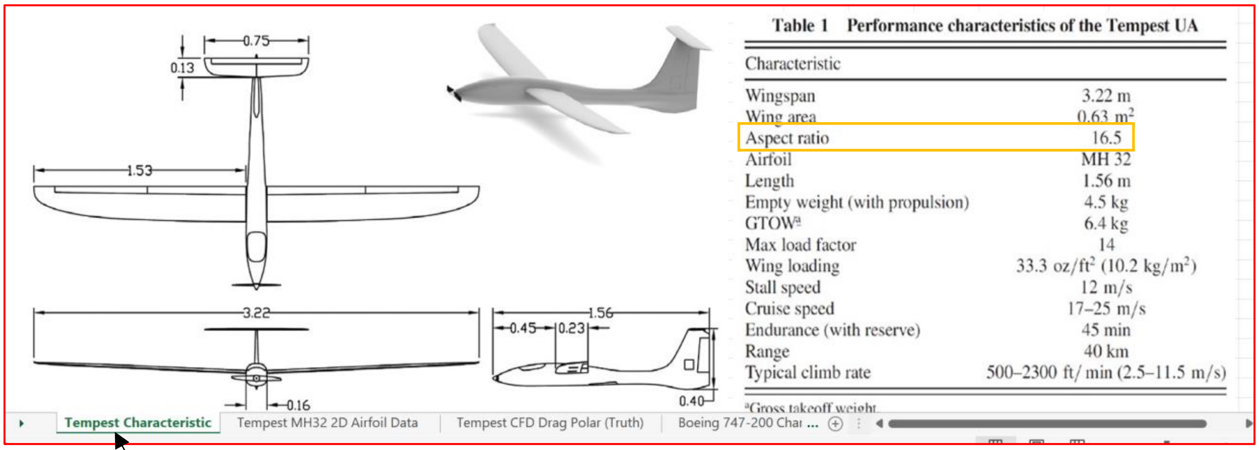


Table 1 Performance characteristics of the Tempest UA

Characteristic	
Wingspan	3.22 m
Wing area	0.63 m^2
Aspect ratio	16.5
Airfoil	MH 32
Length	1.56 m
Empty weight (with propulsion)	4.5 kg
GTOW[a]	6.4 kg
Max load factor	14
Wing loading	33.3 oz/ft^2 (10.2 kg/m^2)
Stall speed	12 m/s
Cruise speed	17–25 m/s
Endurance (with reserve)	45 min
Range	40 km
Typical climb rate	500–2300 ft/ min (2.5–11.5 m/s)

[a] Gross takeoff weight

1st tab for Tempest geometry or 4th tab for Boeing 747 geometry. AR is given in the table on the right.

Now all variables are known to determine the 3D lift-curve slope (a).

$$a = \frac{dC_L}{d\alpha} = \frac{a_o}{1+\frac{57.3\cdot a_o}{\pi\cdot e\cdot AR}} \tag{1}$$

What is α?

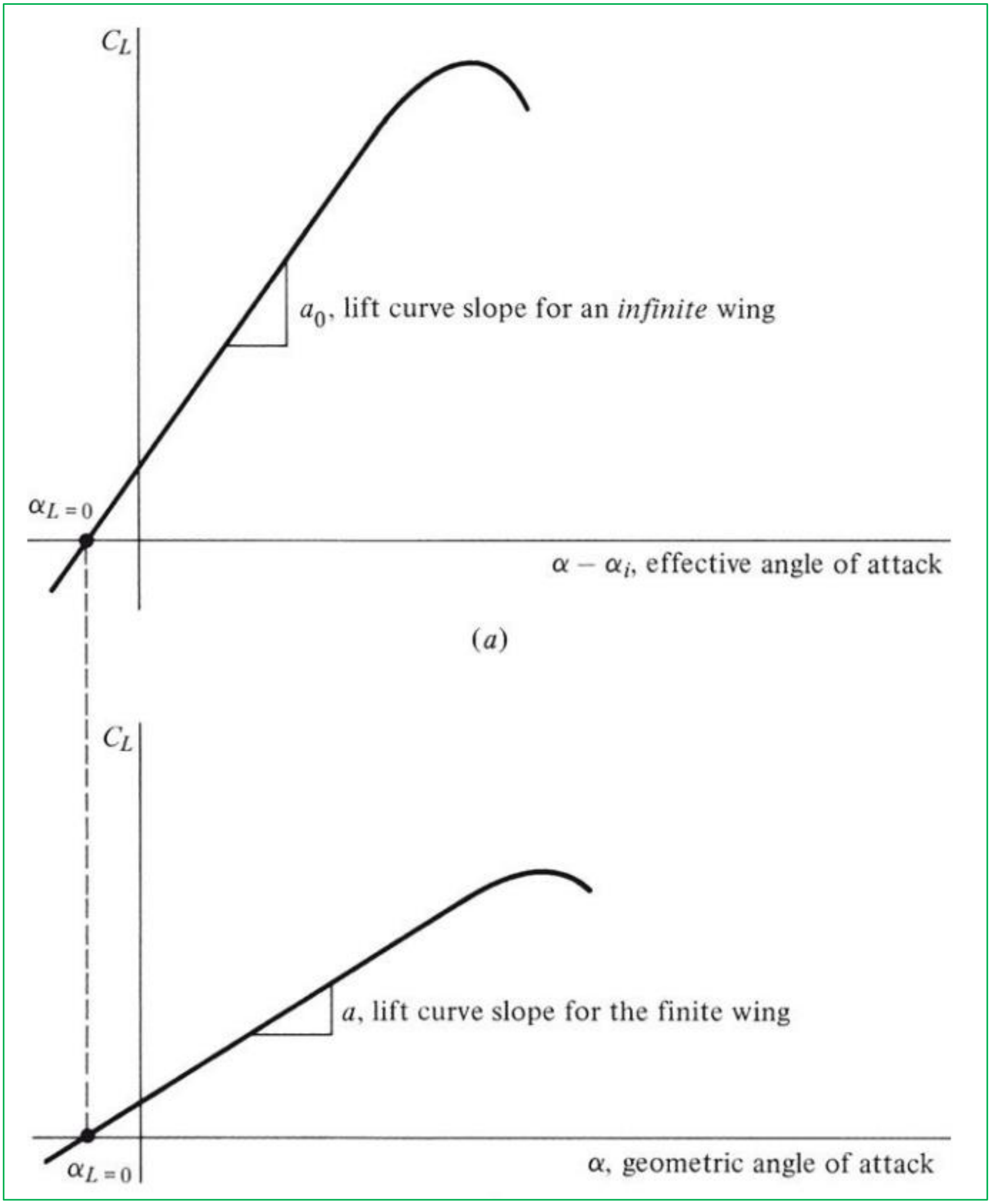
$$C_L = a \cdot (\boxed{\alpha} - \alpha_{L=0}) \tag{2}$$

Literally just the vector of angle of attack values from the given data. i.e. same x-axis values, different lift coefficient from before.

What is $\alpha_{L=0}$?

$$C_L = a \cdot (\alpha - \boxed{\alpha_{L=0}}) \tag{2}$$

$\alpha_{L=0}$ is the angle of attack at which no lift is generated (i.e. the x-intercept, or root, of the C_L vs α curve). We assume this value is exactly the same between 2D and 3D (as seen from the vertical dashed line in Figure 3)



So you can use the x-intercept of what you did in Step 1A. You can find the x-intercept of either

- The original, given data (least accurate)
- Your interpolation or best-fit line OF that data (more accurate)

Now plot C_L on top of the previous one, with the same range of AOA values. This new one is for 3D wing.