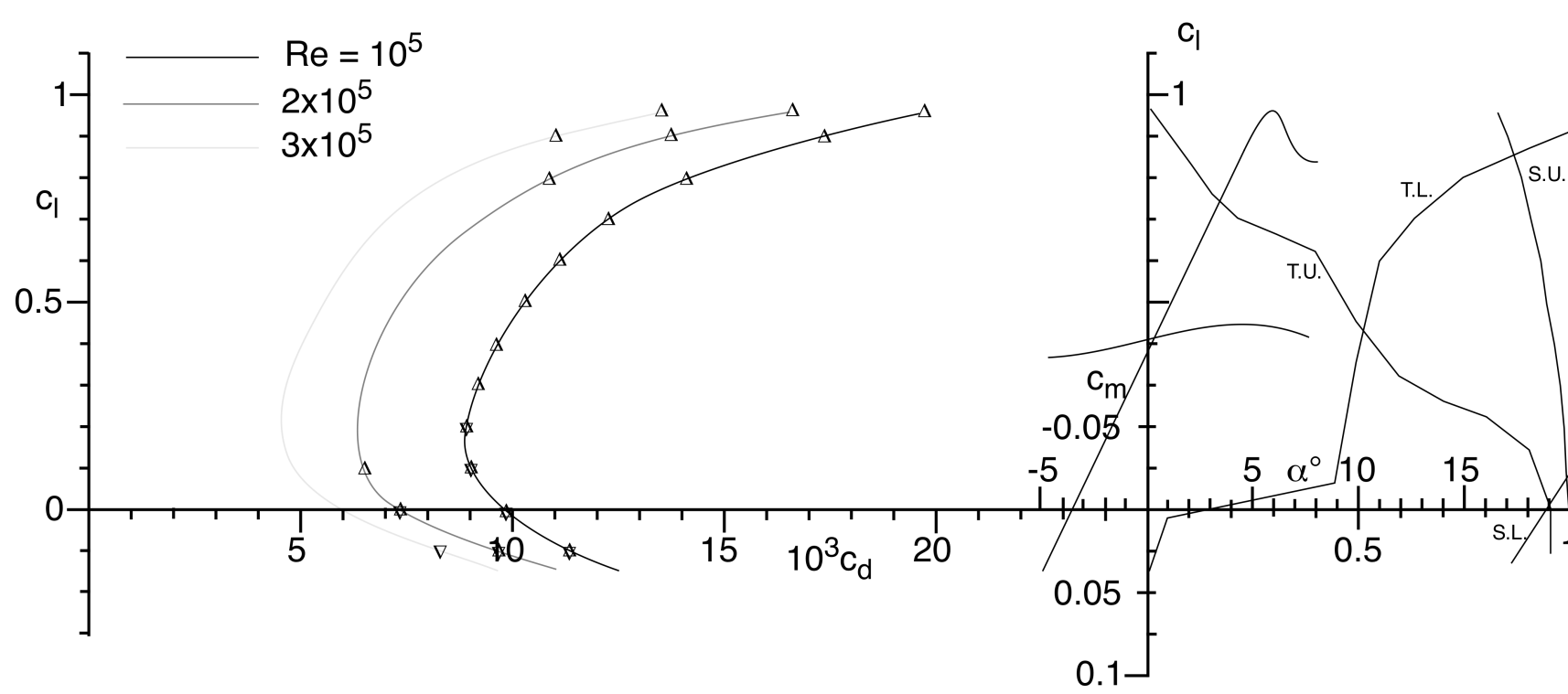


Generic polar



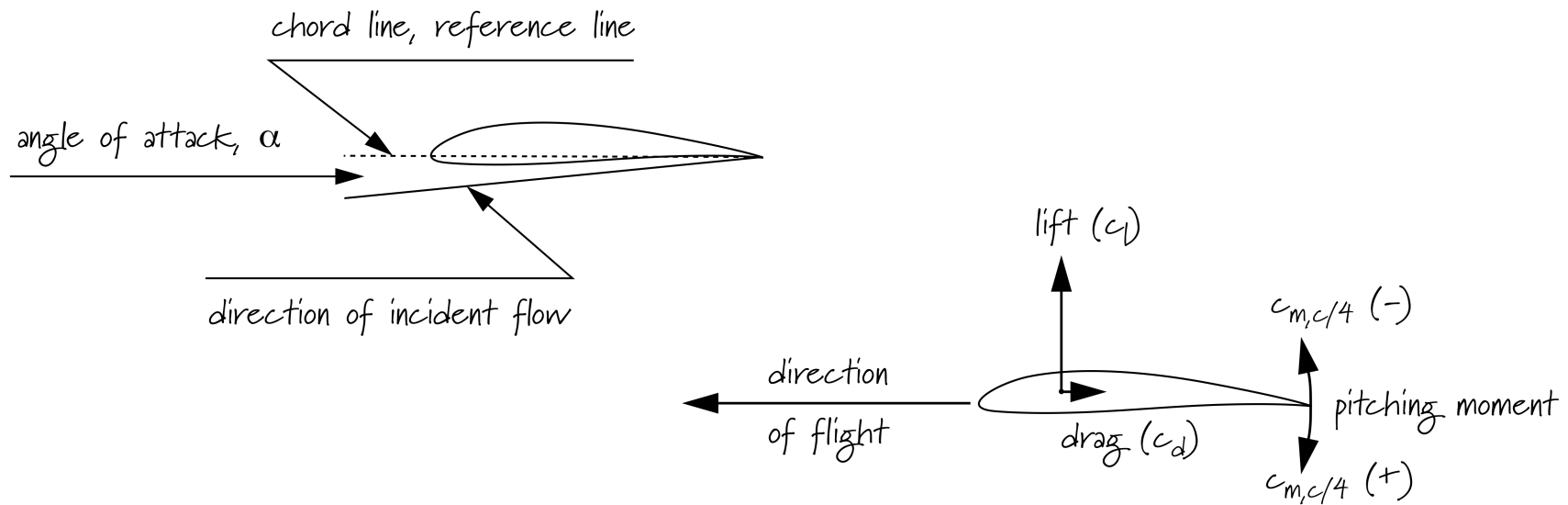
$Re = 10^5 = 100,000$

$Re = 2 \times 10^5 = 200,000$

$Re = 3 \times 10^5 = 300,000$

Polar shows from left to right (1) C_d , (2) C_l and (3) $C_{m,c/4}$, and bubble warning locations as % chord

Definitions



Notes:

- (1) The angle of attack is measured as the angle of the datum line (chord line) to the freestream flow.
[Exception! Induced angle of attack is measured by the location of the stagnation point.]
- (2) Lift is always measured perpendicular to the freestream flow.
- (3) Drag is always measured parallel to the freestream flow.
- (4) The pitching moment is measured as a rotational force about the $c/4$ point on the chord line.

Exercise #1:

- (1) Find the stalling speed of the sailplane,
- (2) and the angle of attack and Reynolds number at which it occurs.
- (3) Then find the c_d and actual angle of attack of the sailplane wing section at a C_L of 0.5.

Exercise #2:

- (1) Find the moment coefficient ($c_{m,c/4}$) of the wing section at best c_l/c_d for a specific Reynolds number of your choosing.
- (2) Determine the velocity for that Reynolds number,
- (3) then find the wing loading needed to achieve this performance.

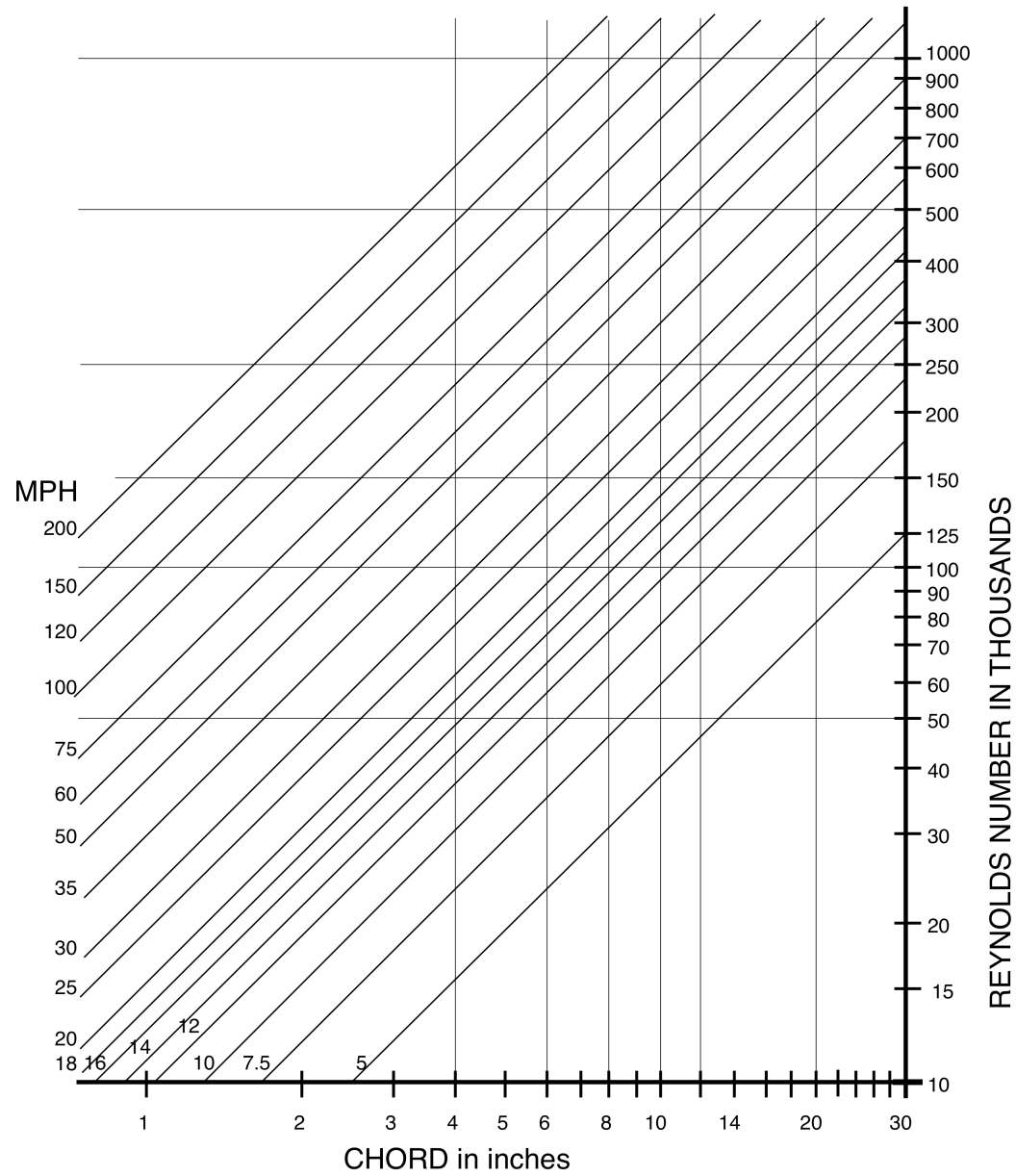
Exercise #3:

- (1) Find the velocity of your sailplane for each of the polar c_d curves.
- (2) Then construct a polar diagram for your model which relates the section c_d to the sailplane C_L at each of these velocities.
- (3) Finally, construct another polar diagram which simply relates c_d to $c_{l,opt}$.

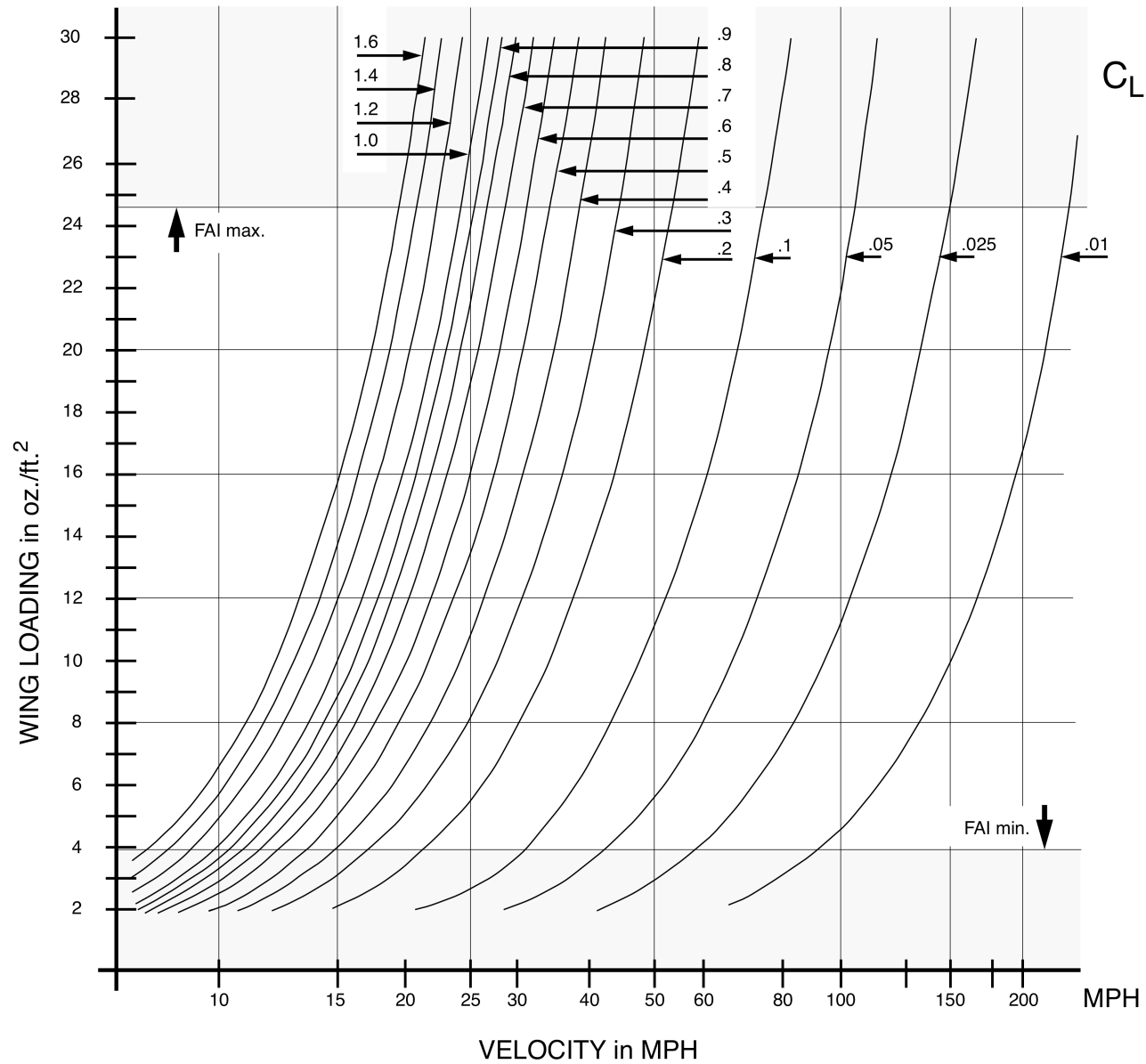
Exercise #4:

- (1) Assume a tailless sailplane using the EH 2,0/10,0 airfoil across the span. (The section polar is reproduced on later pages.)
- (2) The span is 100" and the chord is a constant 10". The fuselage has a constant c_d of 0.005.
- (3) The glider weighs 75 ounces.
- (4) Determine the aircraft maximum L/D.

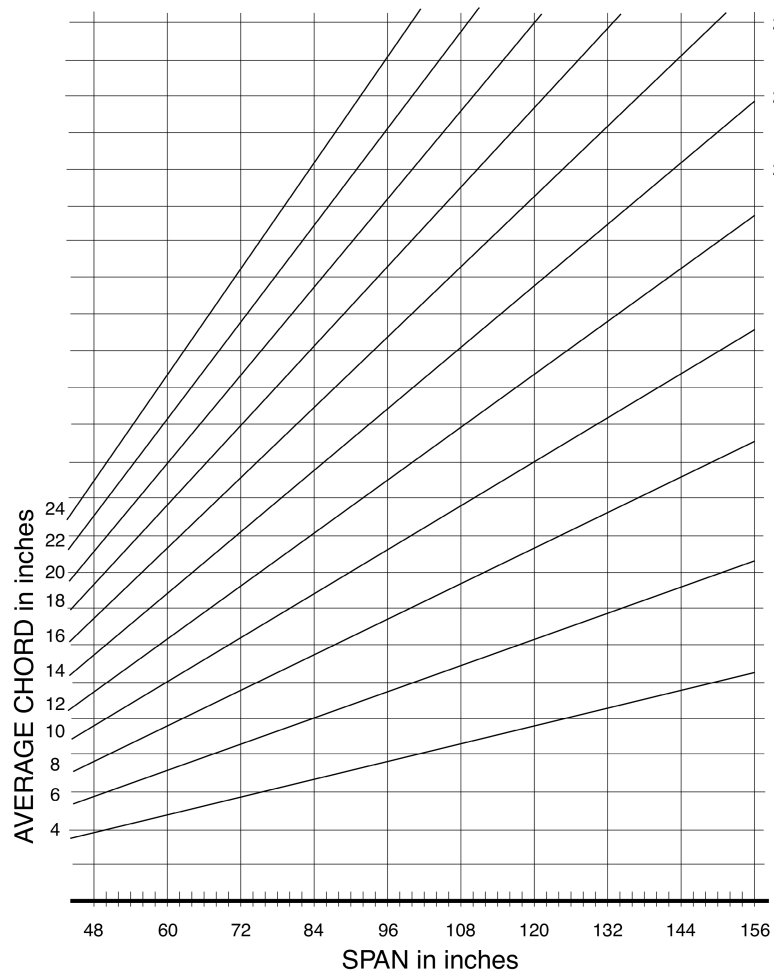
Reynolds number vs Chord vs MPH



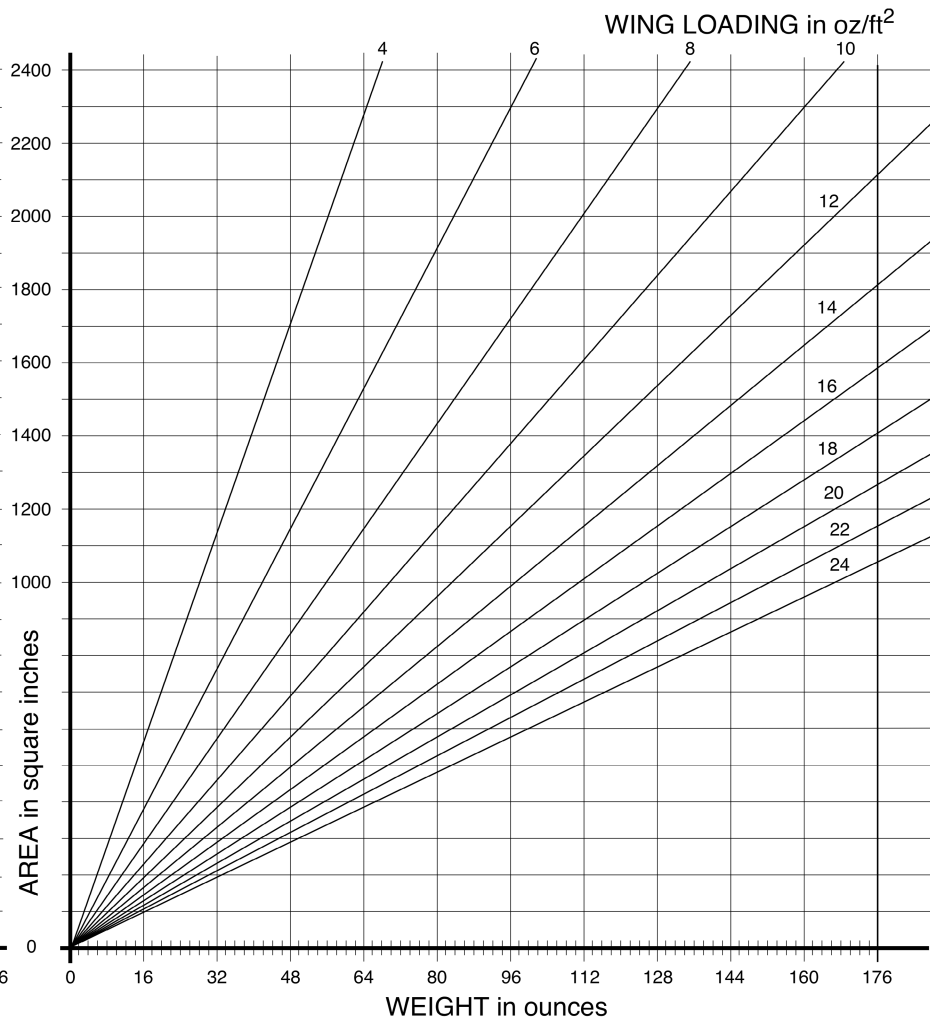
Lift coefficient vs Velocity vs Wing loading



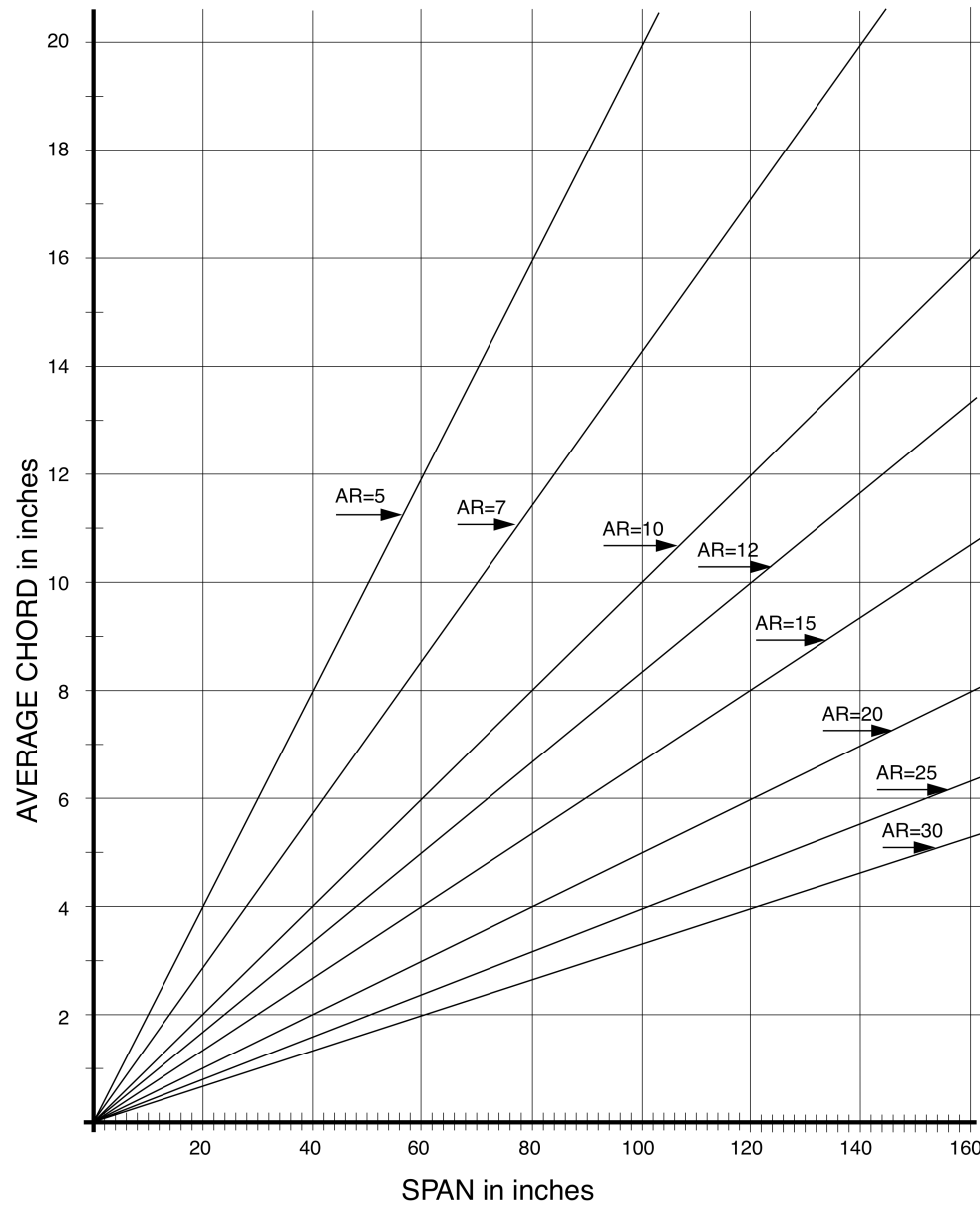
(L) Chord vs Span vs Area



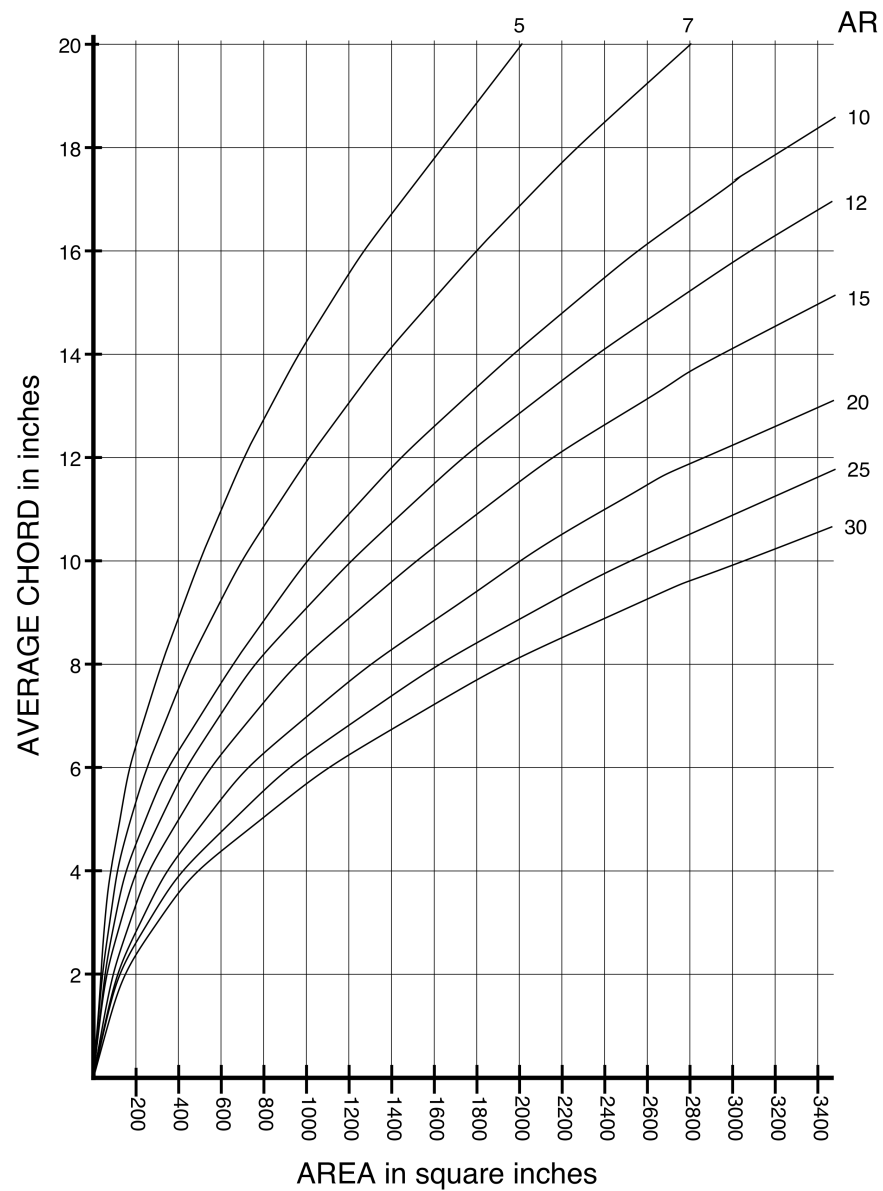
(R) Area vs Weight vs Wing loading



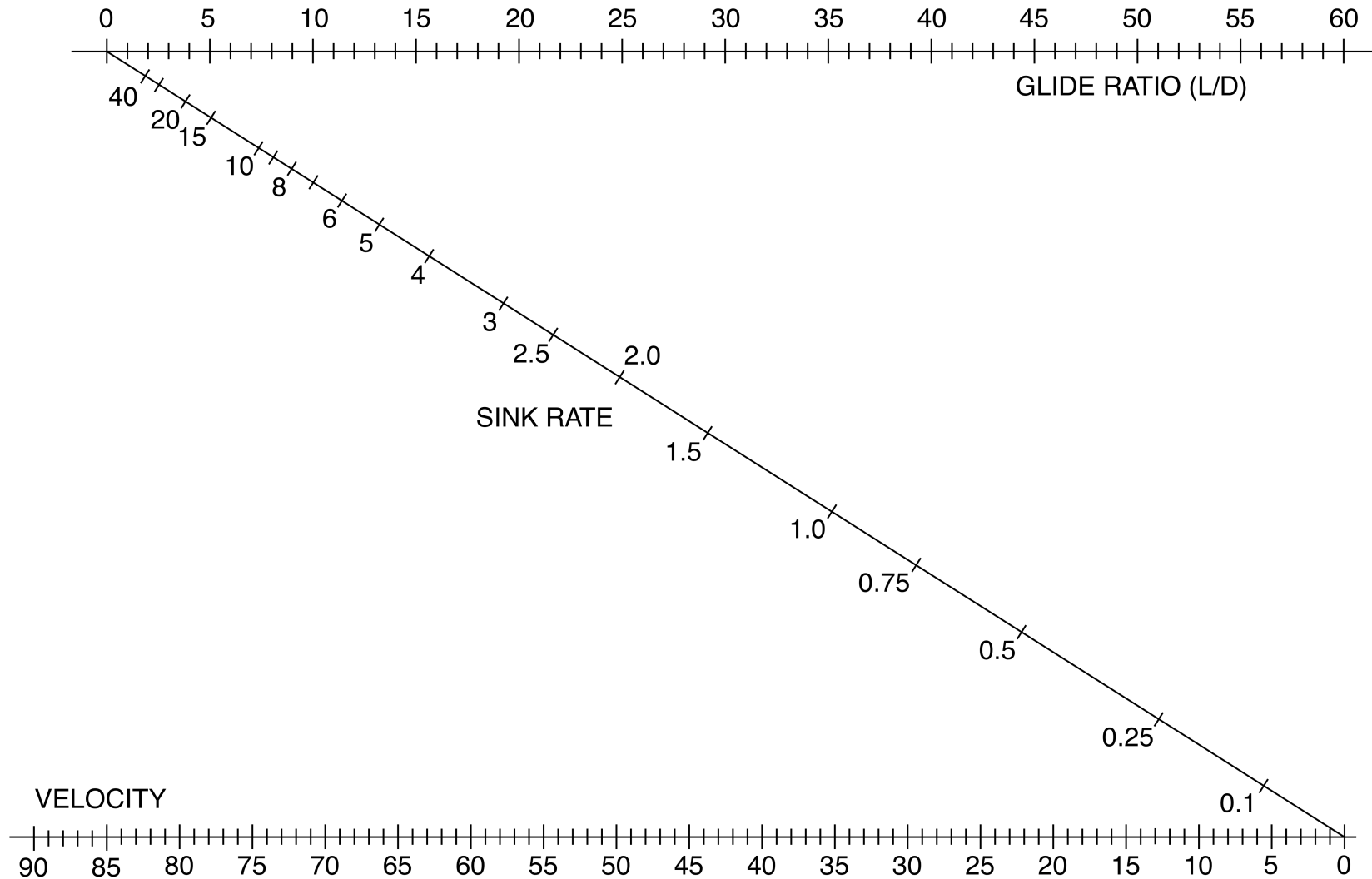
Average chord vs Span vs Aspect ratio



Average chord vs Area vs Aspect ratio



Velocity vs Glide ratio vs Sink rate



Aspect ratio vs Lift coefficient vs Induced drag coefficient

		<u>LIFT COEFFICIENT</u>																	
		<u>.1</u>	<u>.2</u>	<u>.3</u>	<u>.4</u>	<u>.5</u>	<u>.6</u>	<u>.7</u>	<u>.8</u>	<u>.9</u>	<u>1.0</u>	<u>1.1</u>	<u>1.2</u>	<u>1.3</u>	<u>1.4</u>	<u>1.5</u>	<u>1.6</u>	<u>1.7</u>	<u>1.8</u>
A S P E C T R A T I O	5	.0006	.0025	.0057	.0102	.0159	.0229	.0312	.0407	.0516	.0637	.0770	.0917	.1076	.1248	.1432	.1630	.1840	.2063
	7	.0005	.0018	.0041	.0073	.0114	.0164	.0223	.0291	.0368	.0455	.0550	.0655	.0768	.0891	.1023	.1164	.1314	.1473
	10	.0003	.0013	.0029	.0051	.0080	.0115	.0156	.0204	.0258	.0318	.0385	.0458	.0538	.0624	.0716	.0815	.0920	.1031
	12	.0003	.0011	.0024	.0042	.0066	.0095	.0130	.0170	.0215	.0265	.0321	.0382	.0448	.0520	.0597	.0679	.0767	.0859
	15	.0002	.0008	.0019	.0034	.0053	.0076	.0104	.0136	.0172	.0212	.0257	.0306	.0359	.0416	.0477	.0543	.0613	.0688
	20	.0002	.0006	.0014	.0025	.0040	.0057	.0078	.0102	.0129	.0159	.0193	.0229	.0269	.0312	.0358	.0407	.0460	.0516
	25	.0001	.0005	.0011	.0020	.0032	.0046	.0062	.0081	.0103	.0127	.0154	.0183	.0215	.0250	.0286	.0326	.0368	.0413
	30	.0001	.0004	.0010	.0017	.0027	.0038	.0052	.0068	.0086	.0106	.0128	.0153	.0179	.0208	.0239	.0272	.0307	.0344

INDUCED DRAG COEFFICIENT AS RELATED TO ASPECT RATIO AND LIFT COEFFICIENT

Lift coefficient vs Drag coefficient vs Lift to drag ratio (l/d or L/D)

		LIFT COEFFICIENT																	
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
D R A G C O E F F I C I E N T	0.001	100.0	200.0	300.0	400.0	500.0	600.0	700.0	800.0	900.0	1000	1100	1200	1300	1400	1500	1600	1700	1800
	0.002	50.0	100.0	150.0	200.0	250.0	300.0	350.0	400.0	450.0	500.0	550.0	600.0	650.0	700.0	750.0	800.0	850.0	900.0
	0.003	33.3	66.7	100.0	133.3	166.7	200.0	233.3	266.7	300.0	333.3	366.7	400.0	433.3	466.7	500.0	533.3	566.7	600.0
	0.004	25.0	50.0	75.0	100.0	125.0	150.0	175.0	200.0	225.0	250.0	275.0	300.0	325.0	350.0	375.0	400.0	425.0	450.0
	0.005	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0	240.0	260.0	280.0	300.0	320.0	340.0	360.0
	0.006	16.7	33.3	50.0	66.7	83.3	100.0	116.7	133.3	150.0	166.7	183.3	200.0	216.7	233.3	250.0	266.7	283.3	300.0
	0.007	14.3	28.6	42.9	57.1	71.4	85.7	100.0	114.3	128.6	142.9	157.1	171.4	185.7	200.0	214.3	228.6	242.9	257.1
	0.008	12.5	25.0	37.5	50.0	62.5	75.0	87.5	100.0	112.5	125.0	137.5	150.0	162.5	175.0	187.5	200.0	212.5	225.0
	0.009	11.1	22.2	33.3	44.4	55.6	66.7	77.8	88.9	100.0	111.1	122.2	133.3	144.4	155.6	166.7	177.8	188.9	200.0
	0.010	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0	160.0	170.0	180.0
	0.011	9.1	18.2	27.3	36.4	45.5	54.5	63.6	72.7	81.8	90.9	100.0	109.1	118.2	127.3	136.4	145.5	154.5	163.6
	0.012	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0	83.3	91.7	100.0	108.3	116.7	125.0	133.3	141.7	150.0
	0.013	7.7	15.4	23.1	30.8	38.5	46.2	53.8	61.5	69.2	76.9	84.6	92.3	100.0	107.7	115.4	123.1	130.8	138.5
	0.014	7.1	14.3	21.4	28.6	35.7	42.9	50.0	57.1	64.3	71.4	78.6	85.7	92.9	100.0	107.1	114.3	121.4	128.6
	0.015	6.7	13.3	20.0	26.7	33.3	40.0	46.7	53.3	60.0	66.7	73.3	80.0	86.7	93.3	100.0	106.7	113.3	120.0
	0.016	6.2	12.5	18.8	25.0	31.3	37.5	43.8	50.0	56.3	62.5	68.8	75.0	81.3	87.5	93.8	100.0	106.3	112.5
	0.017	5.9	11.8	17.6	23.5	29.4	35.3	41.2	47.1	52.9	58.8	64.7	70.6	76.5	82.4	88.2	94.1	100.0	105.9
	0.018	5.6	11.1	16.7	22.2	27.8	33.3	38.9	44.4	50.0	55.6	61.1	66.7	72.2	77.8	83.3	88.9	94.4	100.0
	0.019	5.3	10.5	15.8	21.1	26.3	31.6	36.8	42.1	47.4	52.6	57.9	63.2	68.4	73.7	78.9	84.2	89.5	94.7
	0.020	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
	0.021	4.8	9.5	14.3	19.0	23.8	28.6	33.3	38.1	42.9	47.6	52.4	57.1	61.9	66.7	71.4	76.2	81.0	85.7
	0.022	4.5	9.1	13.6	18.2	22.7	27.3	31.8	36.4	40.9	45.5	50.0	54.5	59.1	63.6	68.2	72.7	77.3	81.8
	0.023	4.4	8.7	13.0	17.4	21.7	26.1	30.4	34.8	39.1	43.5	47.8	52.2	56.5	60.9	65.2	69.6	73.9	78.3
	0.024	4.2	8.3	12.5	16.7	20.8	25.0	29.2	33.3	37.5	41.7	45.8	50.0	54.2	58.3	62.5	66.7	70.8	75.0
	0.025	4.0	8.0	12.0	16.0	19.2	24.0	28.0	32.0	36.0	40.0	44.0	48.0	52.0	56.0	60.0	64.0	68.0	72.0
	0.026	3.8	7.7	11.5	15.4	18.5	23.1	26.9	30.8	34.6	38.5	42.3	46.2	50.0	53.8	57.7	61.5	65.4	69.2
	0.027	3.7	7.4	11.1	14.8	18.5	22.2	25.9	29.6	33.3	37.0	40.7	44.4	48.1	51.8	55.5	59.3	63.0	66.7
	0.028	3.6	7.1	10.7	14.3	17.2	21.4	25.0	28.6	32.1	35.7	39.3	42.9	46.4	50.0	53.6	57.1	60.7	64.3
	0.029	3.5	6.9	10.3	13.8	16.7	20.7	24.1	27.6	31.0	34.5	37.9	41.4	44.8	48.3	51.7	55.2	58.6	62.1
	0.030	3.3	6.7	10.0	13.3	16.1	20.0	23.3	26.7	30.0	33.3	36.7	40.0	43.3	46.7	50.0	53.3	56.7	60.0

LIFT TO DRAG RATIO

Angle of attack vs Lift coefficient vs Equivalent angle of attack at AR = 10

		LIFT COEFFICIENT															
		<u>0</u>	<u>.1</u>	<u>.2</u>	<u>.3</u>	<u>.4</u>	<u>.5</u>	<u>.6</u>	<u>.7</u>	<u>.8</u>	<u>.9</u>	<u>1.0</u>	<u>1.1</u>	<u>1.2</u>	<u>1.3</u>	<u>1.4</u>	<u>1.5</u>
A N G L E O F A T T A C K	15	15.00	15.18	15.36	15.55	15.73	15.91	16.09	16.28	16.46	16.64	16.82	17.01	17.19	17.37	17.55	17.74
	14.5	14.50	14.68	14.86	15.05	15.23	15.41	15.59	15.78	15.96	16.14	16.32	16.51	16.69	16.87	17.05	17.24
	14	14.00	14.18	14.36	14.55	14.73	14.91	15.09	15.28	15.46	15.64	15.82	16.01	16.19	16.37	16.55	16.74
	13.5	13.50	13.68	13.86	14.05	14.23	14.41	14.59	14.78	14.96	15.14	15.32	15.51	15.69	15.87	16.05	16.24
	13	13.00	13.18	13.36	13.55	13.73	13.91	14.09	14.28	14.46	14.64	14.82	15.01	15.19	15.37	15.55	15.74
	12.5	12.50	12.68	12.86	13.05	13.23	13.41	13.59	13.78	13.96	14.14	14.32	14.51	14.69	14.87	15.05	15.24
	12	12.00	12.18	12.36	12.55	12.73	12.91	13.09	13.28	13.46	13.64	13.82	14.01	14.19	14.37	14.55	14.74
	11.5	11.50	11.68	11.86	12.05	12.23	12.41	12.59	12.78	12.96	13.14	13.32	13.51	13.69	13.87	14.05	14.24
	11	11.00	11.18	11.36	11.55	11.73	11.91	12.09	12.28	12.46	12.64	12.82	13.01	13.19	13.37	13.55	13.74
	10.5	10.50	10.68	10.86	11.05	11.23	11.41	11.59	11.78	11.96	12.14	12.32	12.51	12.69	12.87	13.05	13.24
	10	10.00	10.18	10.36	10.55	10.73	10.91	11.09	11.28	11.46	11.64	11.82	12.01	12.19	12.37	12.55	12.74
	9.5	09.50	09.68	09.86	10.05	10.23	10.41	10.59	10.78	10.96	11.14	11.32	11.51	11.69	11.87	12.05	12.24
	9	09.00	09.18	09.36	09.55	09.73	09.91	10.09	10.28	10.46	10.64	10.82	11.01	11.19	11.37	11.55	11.74
	8.5	08.50	08.68	08.86	09.05	09.23	09.41	09.59	09.78	09.96	10.14	10.32	10.51	10.69	10.87	11.05	11.24
	8	08.00	08.18	08.36	08.55	08.73	08.91	09.09	09.28	09.46	09.64	09.82	10.01	10.19	10.37	10.55	10.74
	7.5	07.50	07.68	07.86	08.05	08.23	08.41	08.59	08.78	08.96	09.14	09.32	09.51	09.69	09.87	10.05	10.24
	7	07.00	07.18	07.36	07.55	07.73	07.91	08.09	08.28	08.46	08.64	08.82	09.01	09.19	09.37	09.55	09.74
	6.5	06.50	06.68	06.86	07.05	07.23	07.41	07.59	07.78	07.96	08.14	08.32	08.51	08.69	08.87	09.05	09.24
	6	06.00	06.18	06.36	06.55	06.73	06.91	07.09	07.28	07.46	07.64	07.82	08.01	08.19	08.37	08.55	08.74
	5.5	05.50	05.68	05.86	06.05	06.23	06.41	06.59	06.78	06.96	07.14	07.32	07.51	07.69	07.87	08.05	08.24
	5	05.00	05.18	05.36	05.55	05.73	05.91	06.09	06.28	06.46	06.64	06.82	07.01	07.19	07.37	07.55	07.74
	4.5	04.50	04.68	04.86	05.05	05.23	05.41	05.59	05.78	05.96	06.14	06.32	06.51	06.69	06.87	07.05	07.24
	4	04.00	04.18	04.36	04.55	04.73	04.91	05.09	05.28	05.46	05.64	05.82	06.01	06.19	06.37	06.55	06.74
	3.5	03.50	03.68	03.86	04.05	04.23	04.41	04.59	04.78	04.96	05.14	05.32	05.51	05.69	05.87	06.05	06.24
	3	03.00	03.18	03.36	03.55	03.73	03.91	04.09	04.28	04.46	04.64	04.82	05.01	05.19	05.37	05.55	05.74
	2.5	02.50	02.68	02.86	03.05	03.23	03.41	03.59	03.78	03.96	04.14	04.32	04.51	04.69	04.87	05.05	05.24
	2	02.00	02.18	02.36	02.55	02.73	02.91	03.09	03.28	03.46	03.64	03.82	04.01	04.19	04.37	04.55	04.74
	1.5	01.50	01.68	01.86	02.05	02.23	02.41	02.59	02.78	02.96	03.14	03.32	03.51	03.69	03.87	04.05	04.24
	1	01.00	01.18	01.36	01.55	01.73	01.91	02.09	02.28	02.46	02.64	02.82	03.01	03.19	03.37	03.55	03.74
	0.5	00.50	00.68	00.86	01.05	01.23	01.41	01.59	01.78	01.96	02.14	02.32	02.51	02.69	02.87	03.05	03.24
	0	00.00	00.18	00.36	00.55	00.73	00.91	01.09	01.28	01.46	01.64	01.82	02.01	02.19	02.37	02.55	02.74
	-0.5	-0.50	-0.32	-0.14	00.05	00.23	00.41	00.59	00.78	00.96	01.14	01.32	01.51	01.69	01.87	02.05	02.24
	-1	-1.00	-0.82	-0.64	-0.45	-0.27	-0.09	00.09	00.28	00.46	00.64	00.82	01.01	01.19	01.37	01.55	01.74
	-1.5	-1.50	-1.32	-1.14	-0.95	-0.77	-0.59	-0.41	-0.22	-0.04	00.14	00.32	00.51	00.69	00.87	01.05	01.24
	-2	-2.00	-1.82	-1.64	-1.45	-1.27	-1.09	-0.91	-0.72	-0.54	-0.36	-0.18	00.01	00.19	00.37	00.55	00.74
	-2.5	-2.50	-2.32	-2.14	-1.95	-1.77	-1.59	-1.41	-1.22	-1.04	-0.86	-0.68	-0.49	-0.31	-0.13	00.05	00.24
	-3	-3.00	-2.82	-2.64	-2.45	-2.27	-2.09	-1.91	-1.72	-1.54	-1.36	-1.18	-0.99	-0.81	-0.63	-0.45	-0.26
	-3.5	-3.50	-3.32	-3.14	-2.95	-2.77	-2.59	-2.41	-2.22	-2.04	-1.86	-1.68	-1.49	-1.31	-1.13	-0.95	-0.76
	-4	-4.00	-3.82	-3.64	-3.45	-3.27	-3.09	-2.91	-2.72	-2.54	-2.36	-2.18	-1.99	-1.81	-1.63	-1.45	-1.26
	-4.5	-4.50	-4.32	-4.14	-3.95	-3.77	-3.59	-3.41	-3.22	-3.04	-2.86	-2.68	-2.49	-2.31	-2.13	-1.95	-1.76
	-5	-5.00	-4.82	-4.64	-4.45	-4.27	-4.09	-3.91	-3.72	-3.54	-3.36	-3.18	-2.99	-2.81	-2.63	-2.45	-2.26

EQUIVALENT ANGLE OF ATTACK; ASPECT RATIO = 10

