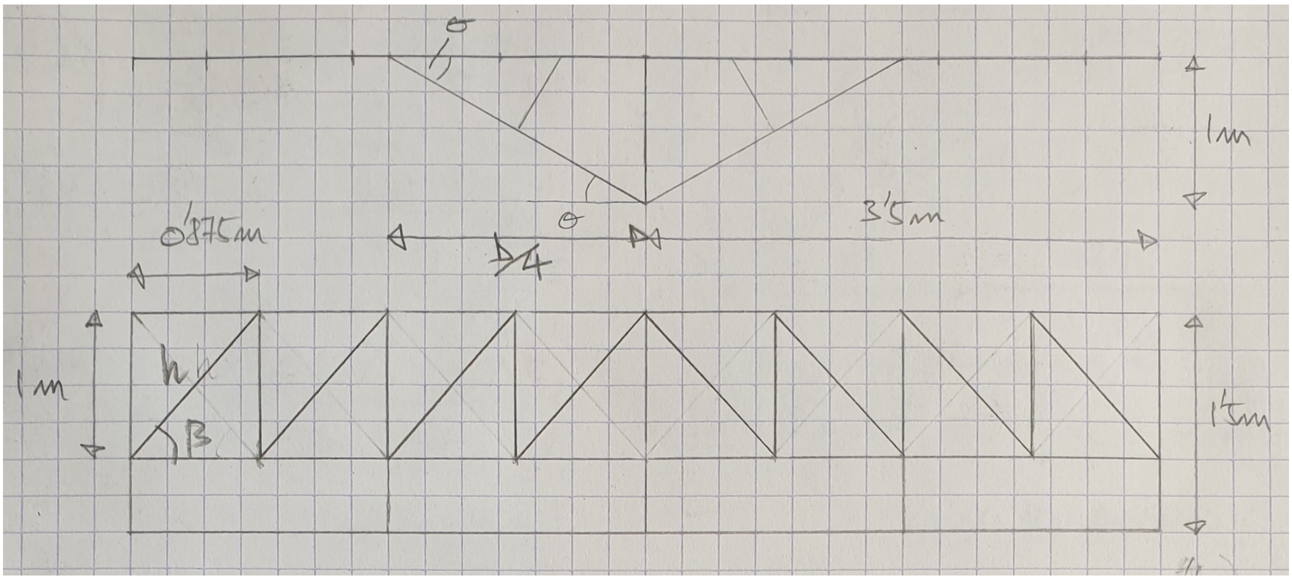
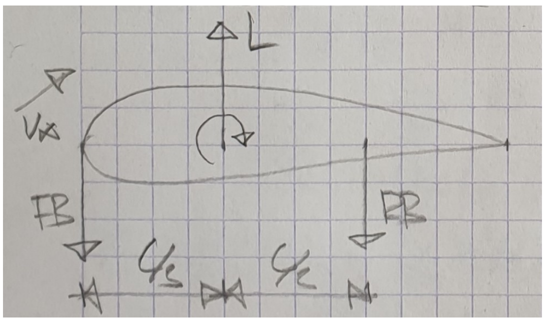


Front and top view of the tube and fabric basic glider wing structure.

The purpose of this exercise is to analize the structure of an aluminum tube and fabric glider wing. A flat lift distribution over the wing is assumed.

Glider specifications;
Wingspan (b) = 7 m
Chord = 1,5 m
Wing area = 7*1,5 = 10,5 m^2
AR = b^2/S = 7^2/(7*1,5) = 7/1,5 = 4,66
MTOW = pilot weight*2 = 70*2 = 140 kgs
Lmax = MTOW*9,81*Load factor*Safety factor = 140*9,81*3,5*1,5 = 7210,35 N
Dmax = Lmax/10 = 721,035 N
Strut length = ((b/4)^2+1^2)^(1/2) = (3,5^2+1)^(1/2) = 2,015 m
h = (1^2+(b/8)^2)^(1/2) = (1+(0,875)^2)^(1/2) = 1,32877 m
Theta = Arctang(1/(b/4)) = arctang (4/b) = arctang (4/7) = 29,74º
Beta = Arcsine(1/1,3287) = 48,81º

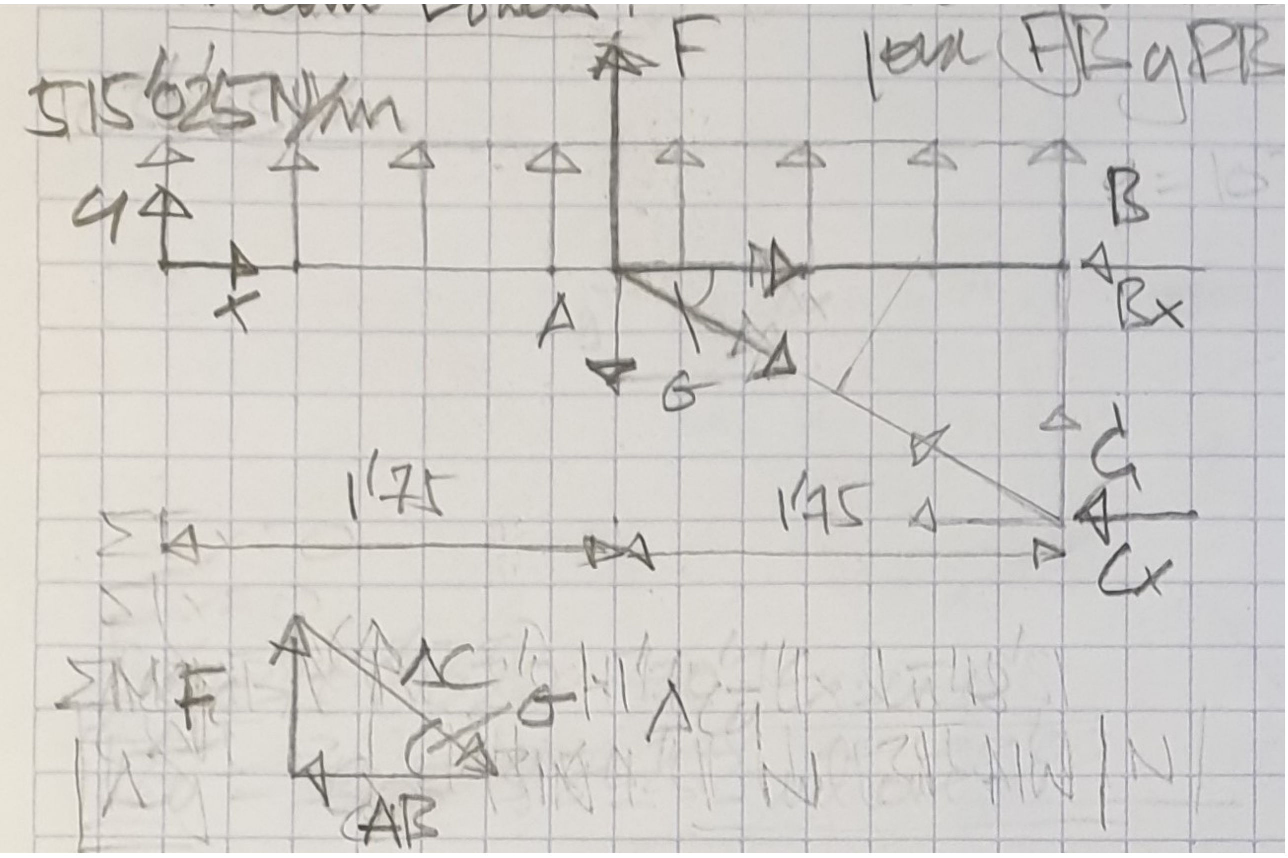
Diagram of the load distribution on each beam/tube for CL max, assuming that the center of pressure is located at C/3;



Sum of vertical forces = Lhalf wing – (RB+FB) = 0
Sum of moments at L (counterclockwise) = RB*CL/3 – FB*CL/3 = 0

RB = FB = Lhalf wing/4 = 7210,35/4 **= 1802,59 N**

Lift distribution for each beam is the same for CL max.
Lift/span distribution on each beam is 1802,59/3,5 **= 515,026 N/m**



Using the vertical force diagram we can calculate the loads on both, the front (FB) and rear (RB) beams/tubes, for CL max.

The loads are concentrated on point A;

Sum of vertical forces = q*b/2 – AC*sine(theta) = 0
AC = 515,025*3,5 / sine(29,74º) = 3633,78 N

Sum of horizontal forces = AC*cosine(theta) – AB = 0
AB = 3633,78*cosine(29,74º) = 3155,16 N

By knowing AB and AC we can size the the beams and the strut for axial loads;
E = 70 Gpa
Strut OD 60*1mm
Area strut = Pi*(Rod^2-Rid^2) = Pi*(0,03^2-0,029^2) **= 0,000185m2**
FB and RB OD 50*1mm
Area FB and RB = Pi*(0,025^2-0,024^2) **= 0,000154m2**
elongation = (force*length)/(E*area)

Strut elongation = (3633,78*2,015)/(70*10^9*0,000185) = **0,000565m**
The elongation of the strut at CL Max is 0,565 mm

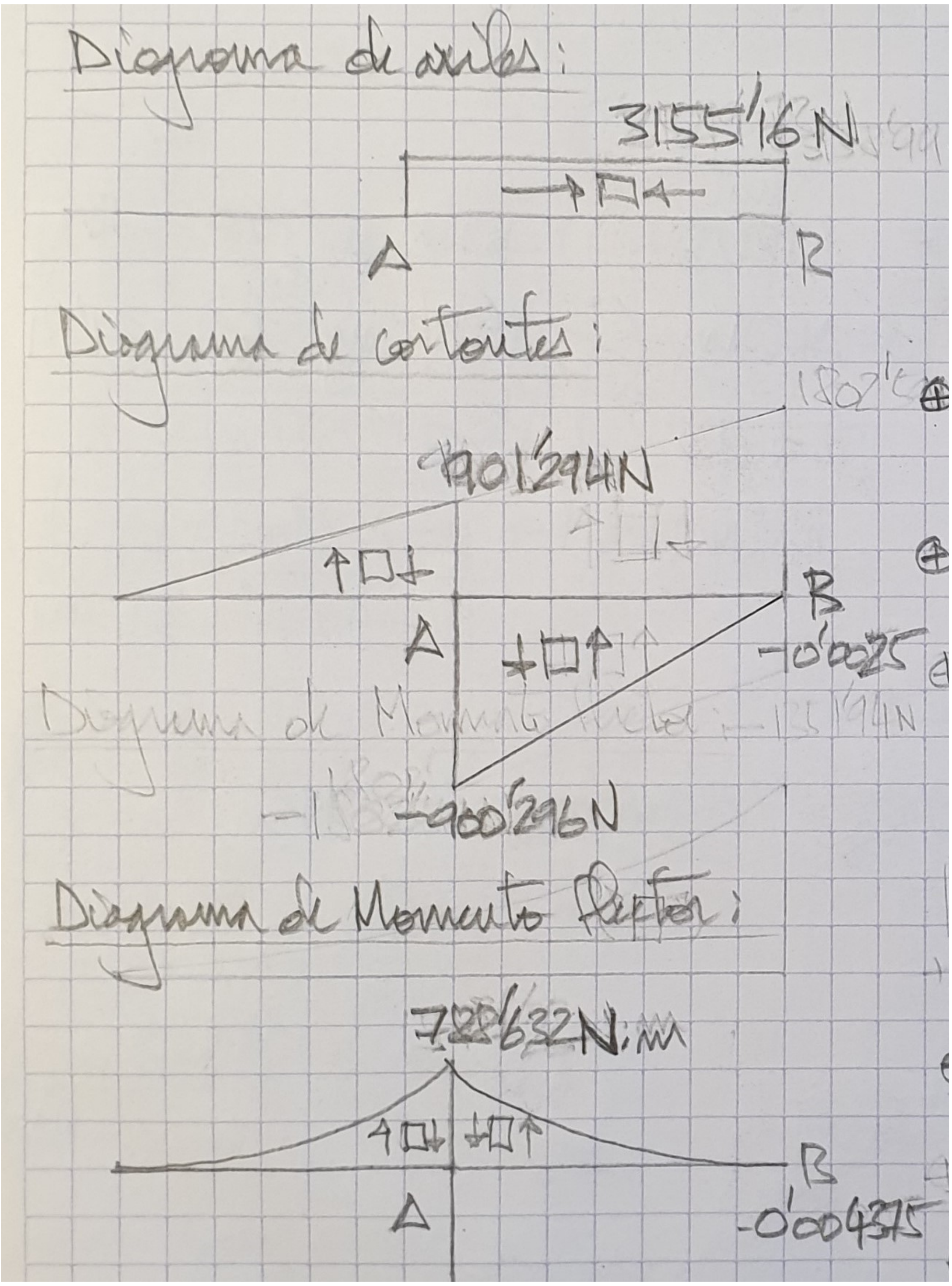
FB and RB elongation = (3155,16*1,75)/(70*10^9*0,000154) = **0,000512 m**
The elongation for the FB and RB at CL Max is 0,512 mm

By knowing the Lift distribution, we can calculate shear and moment over the FB and RB;

Shear;
V = 515,025*x (0,1,75)
V = 515,025*x – 1802,59 (1,75,3,5)

Moment;
M = q*(b/2)*x^2/2 = 515,025*x^2/2 (0,1,75)
M = q*(b/2)*x^2/2 – q*(x-b/2) = 515,025*x^2/2 – 1802,59*(x-1,75) (1,75,3,5)

The Axial, Shear and Moment diagrams, and its respective maximum values are;
It is worth to note that the highest load is that of compression.



By knowing the values of maximum bending and Shear, we can check if the picked areas for resisiting the Axial loads for the FB and RB, are within limits for those loads as well?

Bending;
maximum bending = 788,632N*m
I = Pi/4*(Rod^2-Rid^2) = Pi/4*(0,025^2-0,024^2) = 0,000038
y = 0,025 m
Elastic range/limit Aluminum =100 Mpa

Sigma = (M*y)/I = (788,632*0,025)/0,000038 = 518,837 Kpa
The resulting load is well within limits

Shear;
maximum shear = 901,294 N
I assume that Tau max for aluminum is half of Sigma max = 50 Mpa

Tau = (4*V)/(3*A)*((Rod^2+Rod*Rid+Rid^2)/(Rod+Rid))
Tau = (4*901,294)/(3*0,000154)*((0,025^2+0,025*0,024+0,024^2)/(0,025^2+0,024^2))
Tau = 36005,2/0,000462*1,5204 = 11,70 Mpa
The resulting load is again well within limits.

Wing internal loads:

By knowing the drag distribution over the beam and the axial loads generated by the struts, it is possible to analize the internal loads of the wing.

First we find the external reactions on the root of the wing;
Sum of moments on I (counterclockwise convention) = 0

$Dmax/2*1,75 + 3155,16*1 - Jx = 0$

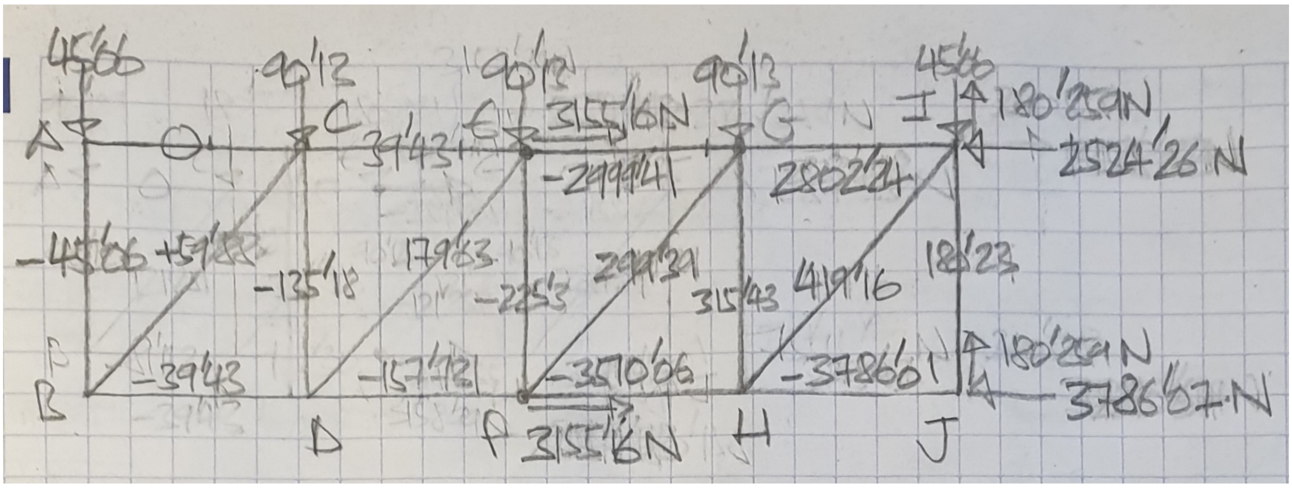
$Jx = 360,518 *1,75 + 3155,16 = 3786,07$ N

Sum of moments on J (counterclockwise convention) = 0

$360,518*1,75 - 3155,16*1 + Ix = 0$

$Ix = 2524,26$ N

Next we can calculate the internal reactions by analizing each node.



The highest load of the internal tubes is 419,16 N

If we consider that all the internal tubes are 25*1mm, we can size them for axial loads;
Area = Pi*(0,0125^2-0,0115^2) = 0,000075 m^2
elongation = 419,2*1,328/(70*10^9*0,000075) = 0,000106 m
The elongation is 0,106 mm

Total weight of the wing structure:

By knowing the length and area of all the tubes we can obtain the total weight of the wings;
Aluminum 6063 weight = 2700kg/m^3
TW = [(length*area) struts+(length*area)FB and RB+(length*area) internal tubes]*alu weight
Total weight = [(3,5*4*0,000154) + (2,015*4*0,000185) + (1,3287*8+1*5*2)*0,000038**]***2700
Total weight = 5,181 + 4,0259 + 4,19 = **13,39 Kgs**