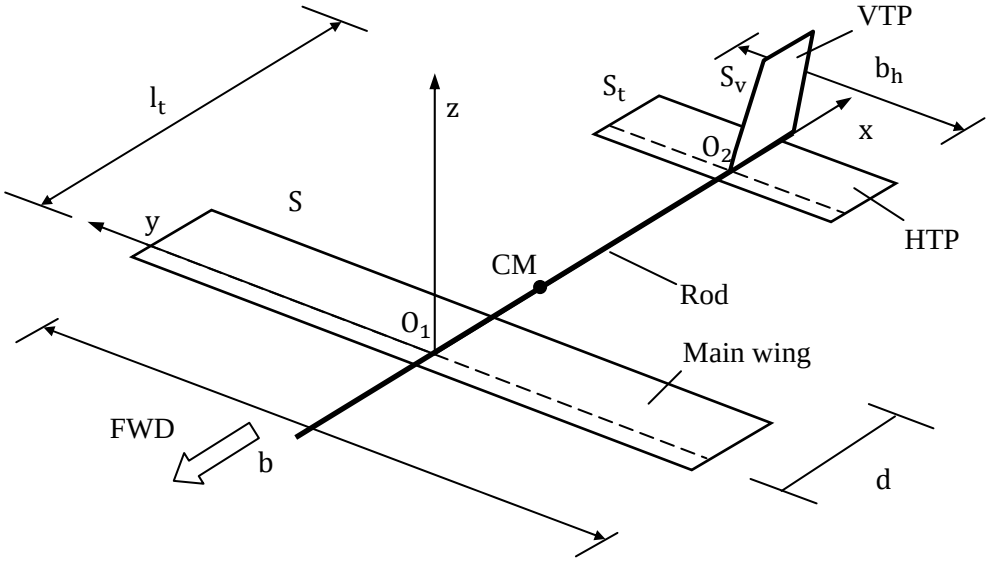
ASSIGNMENT

Teams of maximum 3 people (exceptionally, 4 people)

Deadline: Dec 5th 2017

Description

This work aims at pointing out the ground effect on a glider of conventional configuration, for simplicity, modeled as a wing attached to a horizontal tail plane (HTP) and vertical tail plane (VTP) by means of a thin rod, this last with negligible aerodynamic effect, as sketched in the picture below. Both the wing and HTP are straight (zero sweep angle) and trapezoidal. The following ratios are assumed: $S_t/S = 1/8$, $S_v/S = 2/3$, $l_t/\bar{c} = 4$ ($\bar{c}$ is the mean geometric chord of the wing). The aspect ratios of both the wing and the HTP are left free but high enough (say, above 6) so that the lifting line model can be assumed valid. The tip to chord ratio of each surface is also left free.



The wing is fitted with a NACA 2412 airfoil, and the chord of the center section of the wing is assumed to have zero incidence angle $i_w = 0$ with respect to the rod. The HTP is fitted with a NACA 0009 symmetric airfoil, and its incidence angle with respect to the rod is $i_w = -4°$. The VTP is also fitted with a NACA 0009.

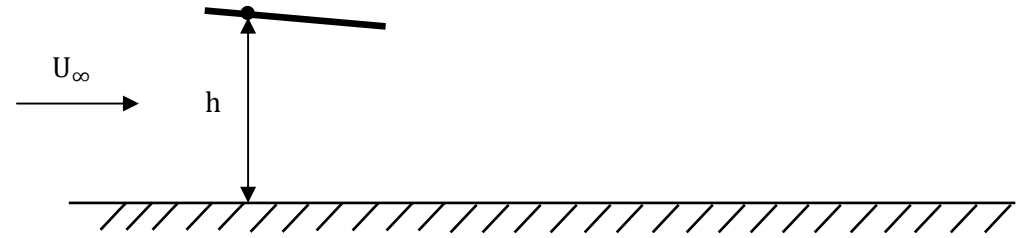
Two alternative methods are acceptable to carry out this work:

- Vortex lattice, or
- Lifting line. In this case, a discrete vortex method must be used so as to determine the zero lift angle of attack of the wing's airfoil.

First, it will be considered the wing isolated.

1. Compute the zero lift angle of attack of the wing (central section) for several values of twist (from 0 to $-8°$), as well as the total drag coefficient, and select an adequate value of twist.
2. Plot the wing's aerodynamic polar ($C_L - C_D$ relationship) corresponding to the angle of attack ranging from 0 to $10°$.

Assume now the wing's 1/4 chord line is at a vertical distance $h = \bar{c}$ from the ground.

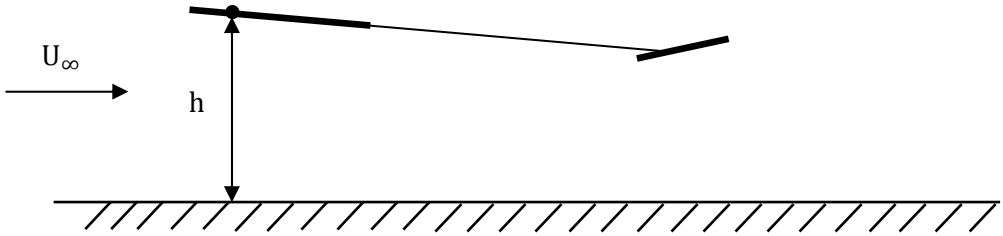


3. Plot the lift coefficient and drag coefficient for an angle of attack $\alpha = 6°$ against the aspect ratio in an interval $0.75A_0 - 1.25A_0$, where A_0 is the nominal aspect ratio used in the previous questions.

Consider now the complete system (wing, HTP, VTP). The HTP is assumed to have zero twist, and the VTP only produces parasitic drag, since no lateral lift is generated on it because of zero sideslip angle $\beta = 0$.

4. The lift and drag coefficients and the required position of the center of mass (distance d between O_1 and CM) so as to achieve longitudinal equilibrium of moments when the angle of attack is 6°.

Assume now the wing's 1/4 chord line is at a vertical distance $h = \bar{c}$ from the (flat) ground.



5. The lift and drag coefficients and the moment coefficient with respect to the center of mass.

Additional data:

NACA 2412

$$C_l = N/A \qquad C_{m_{1/4}} = N/A \qquad C_d = 0.0063 - 0.0033C_l + 0.0067\,C_l^2$$

NACA 0009

$$C_l = N/A \qquad C_{m_{1/4}} = N/A \qquad C_d = 0.0055 + 0.0045\,C_l^2$$