Problem 1

German engineer Karl Wilhem Otto Lilienthal (1848 – 1896) was an aviation pioneer who developed hang gliders, shown in action over his artificial testing hill in figure 1. In the figure diagram, the glider provides a lift and drag $L_{\text{wing}}$ and $D_{\text{wing}}$ applied at the wing’s center of pressure. Herr Otto himself has a drag $D_{\text{Otto}}$ applied at his center of pressure. The overall mass of Herr Otto and the glider is 150 kg and the corresponding weight is applied at the system’s center of gravity.

1. If Herr Otto is gliding at an angle of attack $\alpha = 5^\circ$, determine $L_{\text{wing}}$, $D_{\text{wing}}$ and $D_{\text{Otto}}$.

2. Find the position of the center of pressure of the whole system including Herr Otto and the wing.

Figure 1
Problem 2

A jet of water of density $\rho$ and area $A$ strikes a block and splits into two jets, as shown in Figure 1. Assume the same velocity $V$ for the inlet and the outlets. The upper jet exits at an angle $\theta$ and area $\alpha A$. The lower jet is turned 90° downward. Neglecting fluid weight,

1. derive a formula for the forces $(F_x, F_y)$ required to support the block against fluid momentum changes.

2. Show that $F_y = 0$ only if $\alpha \geq 0.5$.

3. Find the values of $\alpha$ and $\theta$ for which both $F_x$ and $F_y$ are zero.

![Figure 2](image)

Problem 3

An equilateral triangle bar was placed in a uniform stream flows for a drag coefficient test. We observe that a reduced uniform velocity $U/2$ is created downstream, as shown in Figure 2. Pressures $P_1$ and $P_2$ are approximately equal. If the flow is two dimensional and incompressible,

1. Derive a formula for the drag force $D'$ on the bar.

2. Rewrite your result in the form of a dimensionless drag coefficient based on the chord length.

3. Knowing that the pressure coefficient acting on the frontal side of the triangle is $c_{p,1} = 1$ and the pressure coefficient acting on the upper and lower sides is $c_{p,2} = -1$, determine $h$ as a function of $c$. 
Figure 3