Diving depths

January 2015

(a) (b)

Figure 1: (a) Chronophotography of a 3 meters dive, (b) underwater view of the dive.

1 - Evaluate the Reynolds number in the air [figure 1-(a)].

2 - Deduce the aerodynamic force, F_A, which opposes the fall.

3 - Compare F_A to the weight.

4 - From the comparison, deduce the shape of the trajectory in the air and evaluate the velocity U_0 of the diver as he enters the water.

5 - Using the ellipsoïdal diver model presented in figure 2, evaluate the Reynolds number in water figure 1-(b)].

6 - Deduce the hydrodynamic drag force, F_H.

7 - Write the equation of motion of the diver in water.

8 - Integrate this equation in the limit of a vertical water entry, assuming that the density of the diver is equal to the density of water.

9 - Show that $U(s) = U_0 e^{-s/\mathcal{L}}$, where s is the depth. Determine and discuss the characteristic length $\mathcal{L}$.

10 - The depth of a diving pool is chosen to prevent injuries. Choose the depth for a 3m, 10m and 55m (new record) dive. The calculation will be done using $C_D = 1$ for the drag coefficient of the ellipsoid.

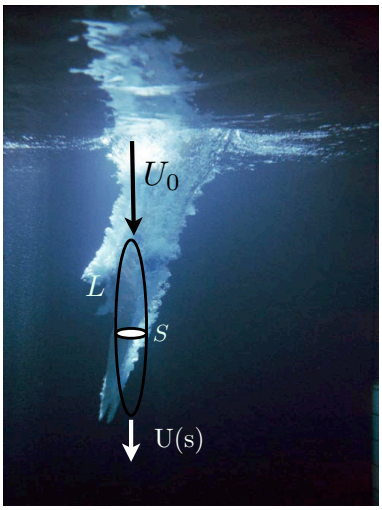

Figure 2: Ellipsoïdal diver model.

11 - Gannets (Fous de Bassan) can dive from a height of 30 metres, achieving speeds of 100 kilometres per hour as they strike the water, enabling them to catch fish much deeper than most airborne birds. Their length is typically 1 m and their weigth 3 kg. An example of dive is presented in figure 3. From this picture, evaluate the drag coefficient of the Gannet. Discuss this value in comparison to that used for a human.

Figure 3: Gannet's dive.

12 - If we assume that the Gannet is a perfect profiled body, what is the expression of the hydrodynamic drag force, F_{Hp} ?

13 - What is the corresponding equation of motion ?

14 - Integrate this equation and discuss the properties of the underwater trajectory compared to the previous exponential behavior.