LA FISICA DELLA VELA

A GENTLE INTRODUCTION

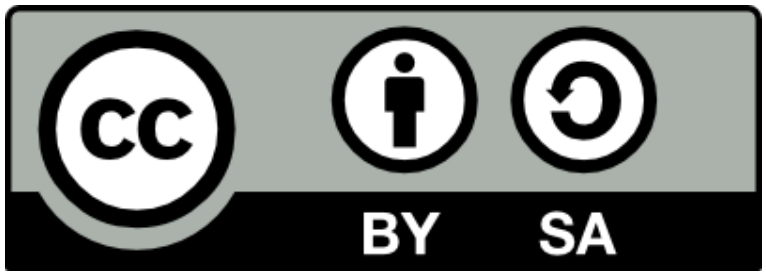
Andrea Vitaletti

VLV ROMA asd

AKUA comunità nautica

DISCLAIMER

- I'm an engineer ... sorry for that ☺
- I'm a modest sailor ... sorry also for that ☺
- A lot of simplifications
- I tried to credit the work by others on links. If something is missing, first of all I'm really sorry, then please point it out



EVOLUZIONE

Vela quadra

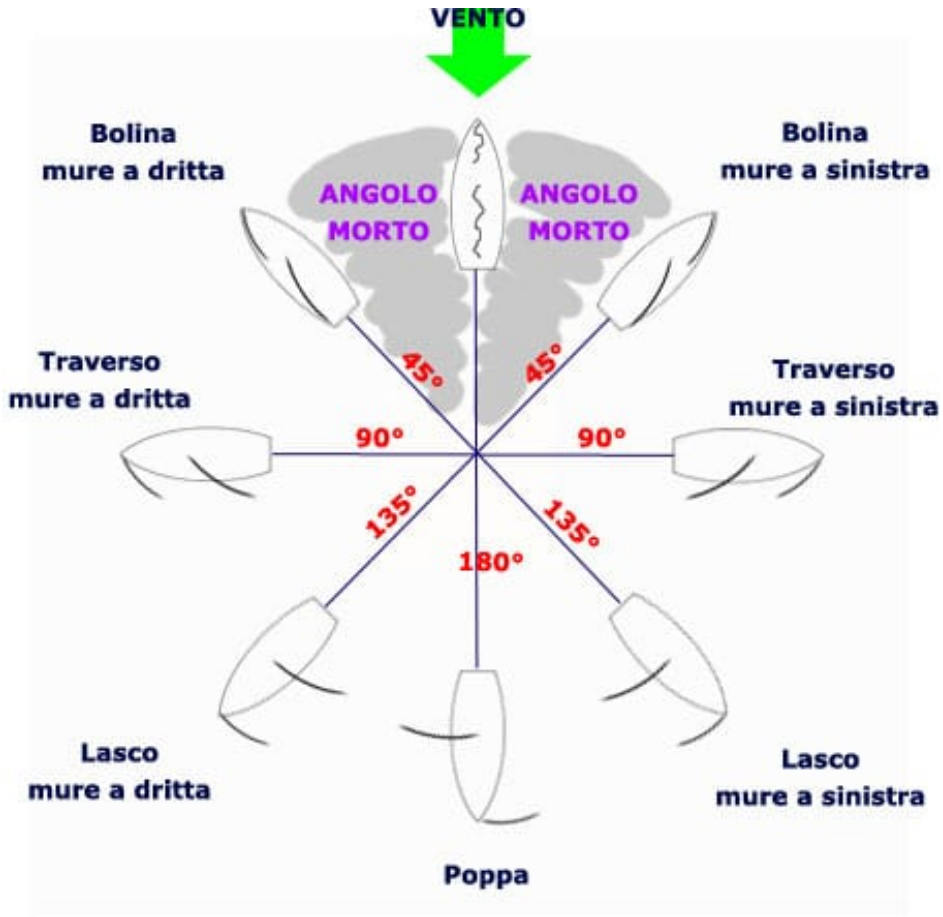
Vela Latina

1961 - WILDCAT USA X-1 1968 - W. Van Alan Clark's Wing C-Class 2013 - GROUPAMA FRA 007

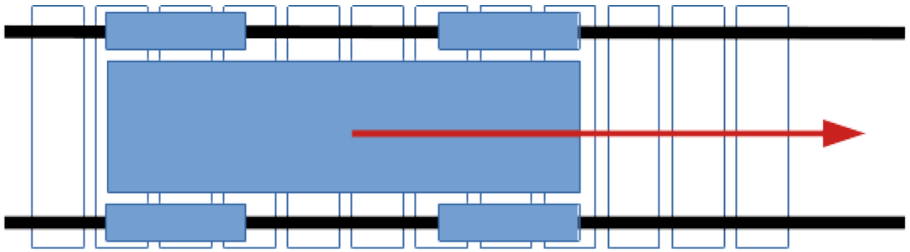
Vela Bermudiana

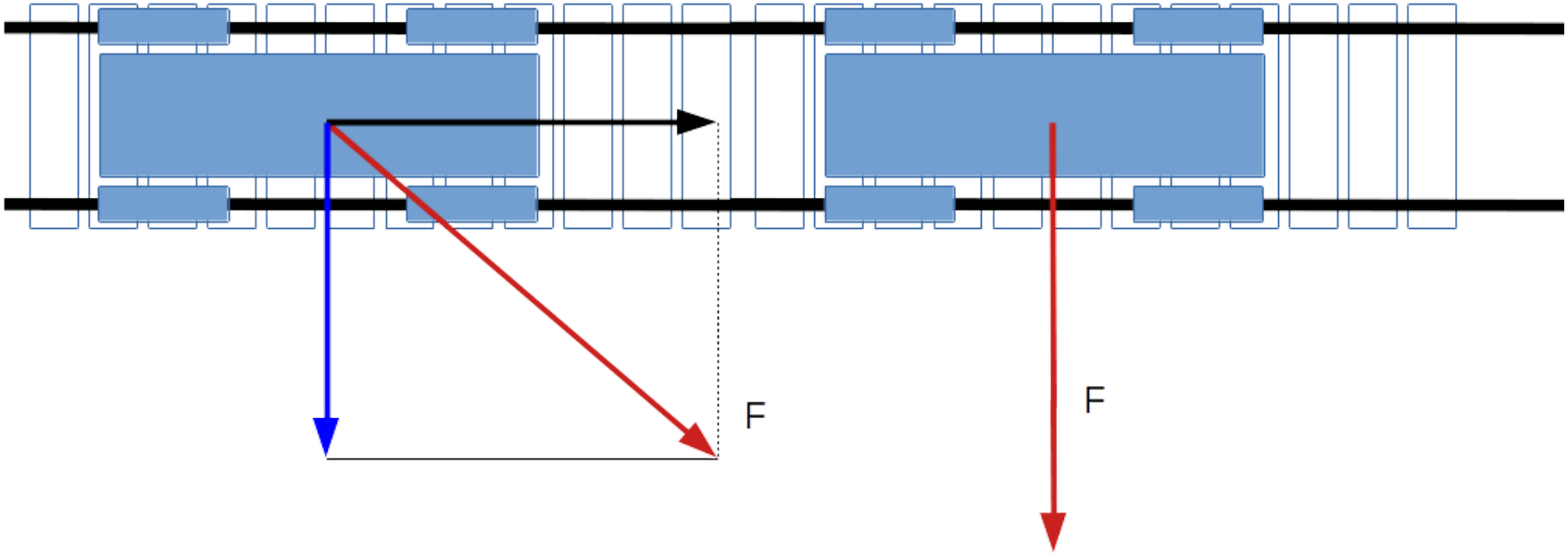
source and source

LE ANDATURE


VENTO
Bolina
mure a dritta
Bolina
mure a sinistra
ANGOLO
MORTO
ANGOLO
MORTO
Traverso
mure a dritta
Traverso
mure a sinistra
45°
45°
90°
90°
135°
135°
180°
Lasco
mure a dritta
Lasco
mure a sinistra
Poppa

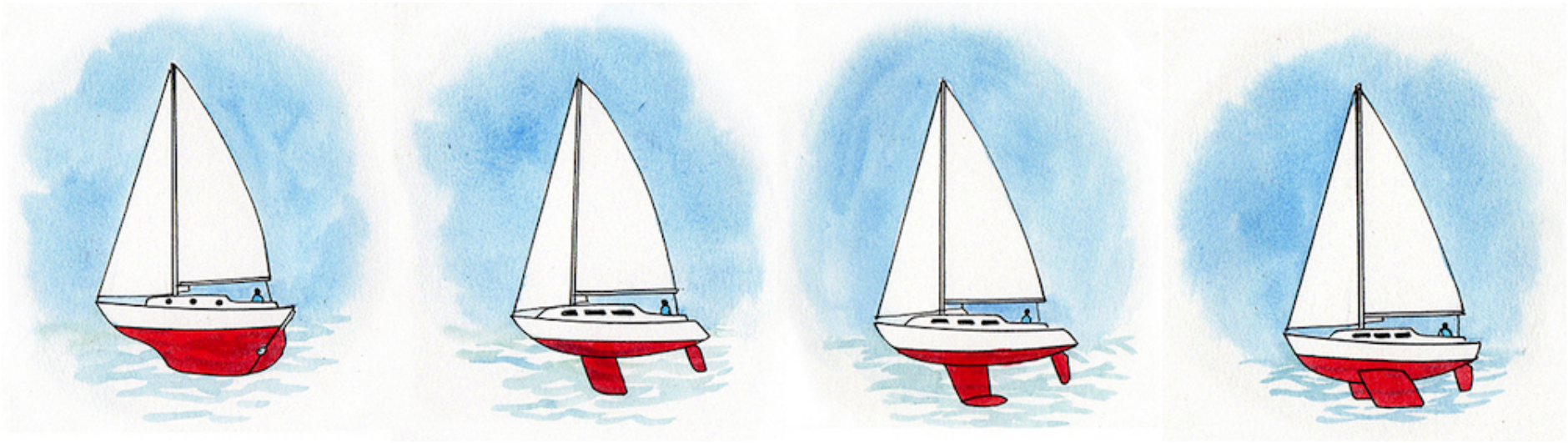
COMINCIAMO DA UN TRENO TRAINATO DA UNA FUNE!





Next slides inspired by this video

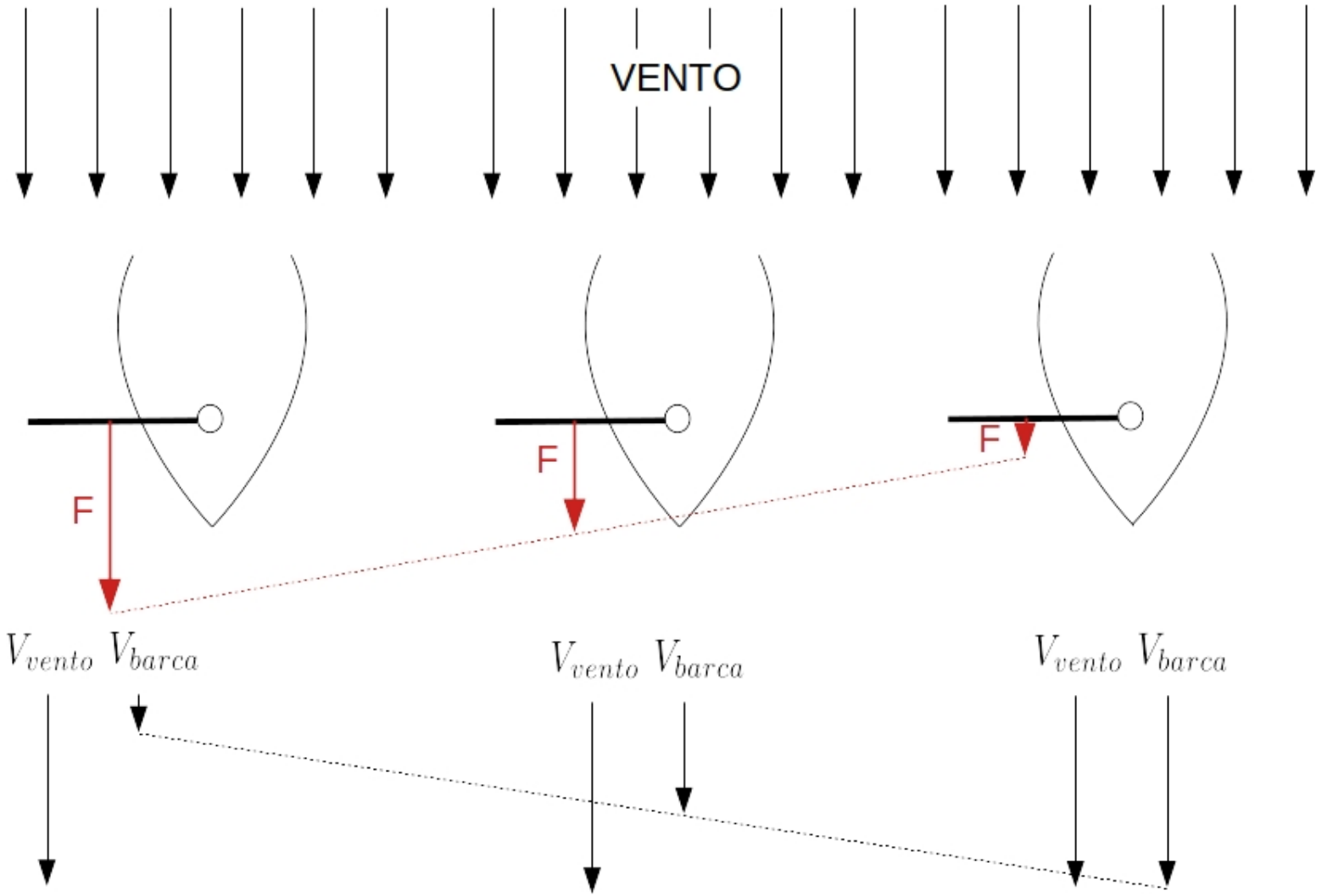
CHI SONO I BINARI?



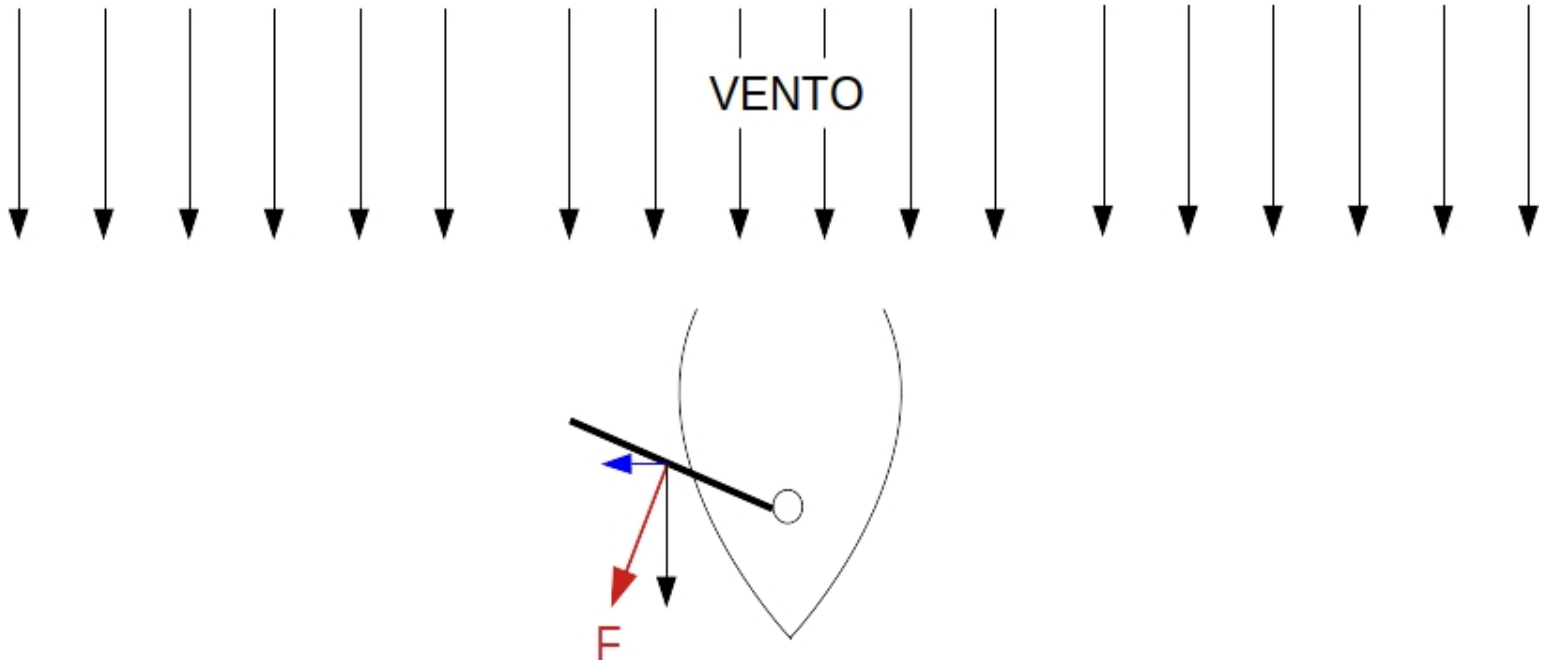
LA FUNE?

VENTO IN POPPA

AL PIÙ LA VELOCITÀ DEL VENTO



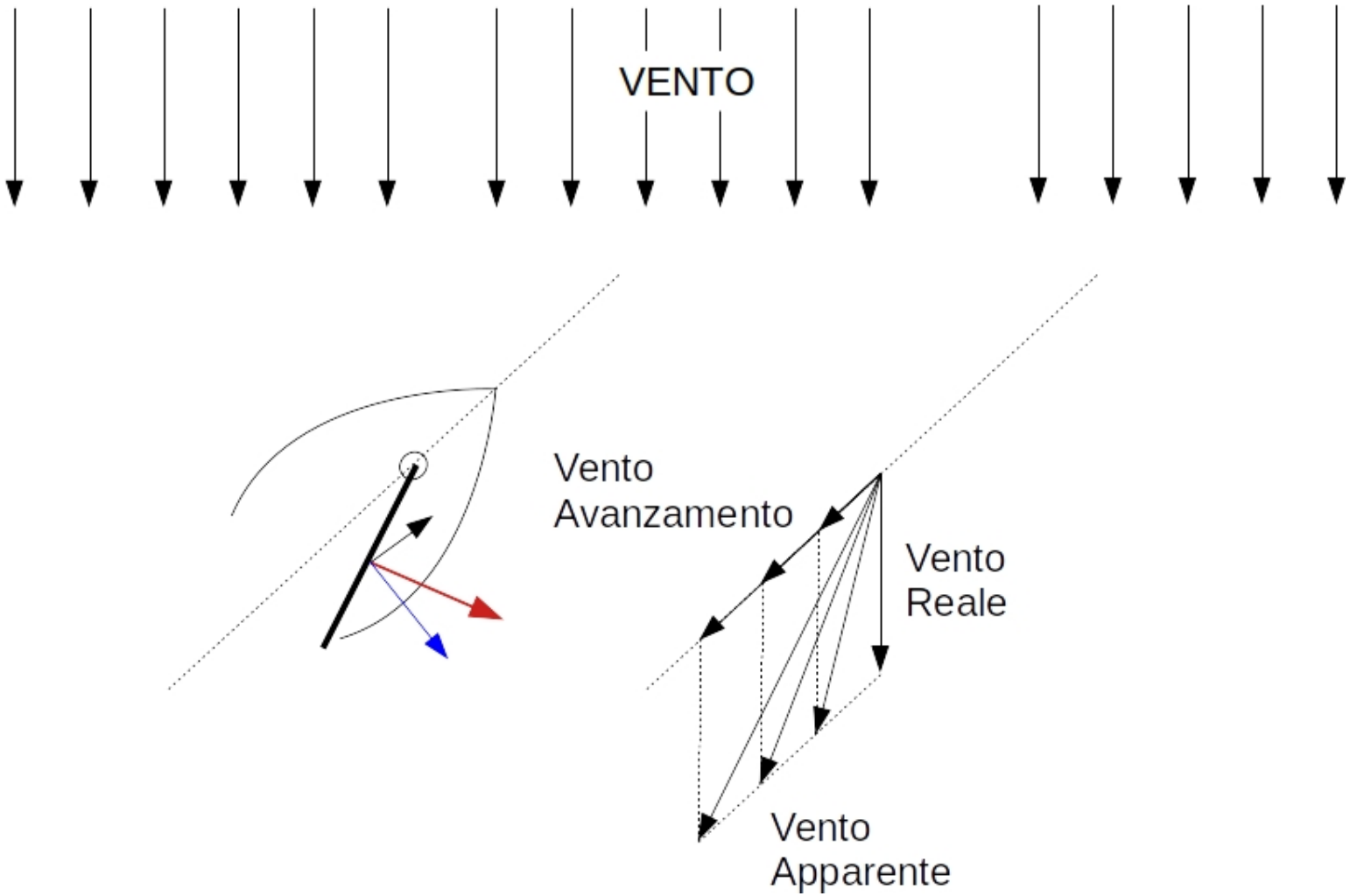
AL PIÙ LA VELOCITÀ DEL VENTO



Forza minore:

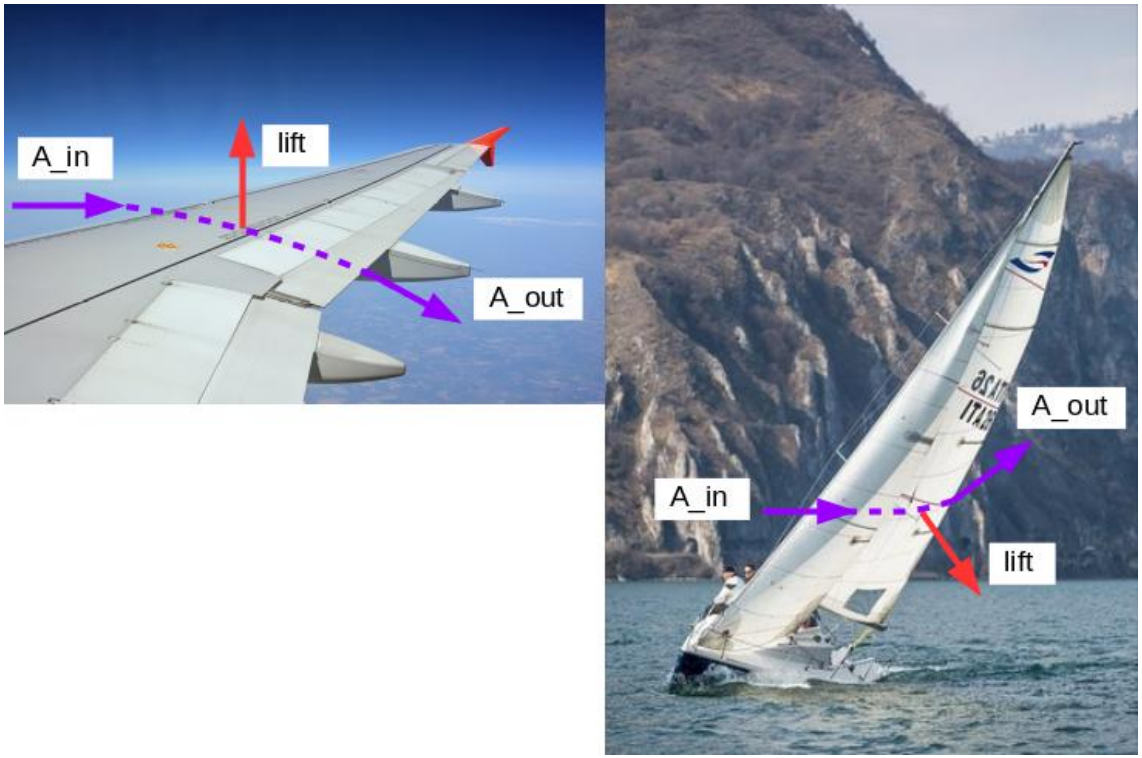
- La vela intercetta meno vento
- Forza perpendicolare alla vela non parallela al moto

PIÙ DELLA VELOCITÀ DEL VENTO



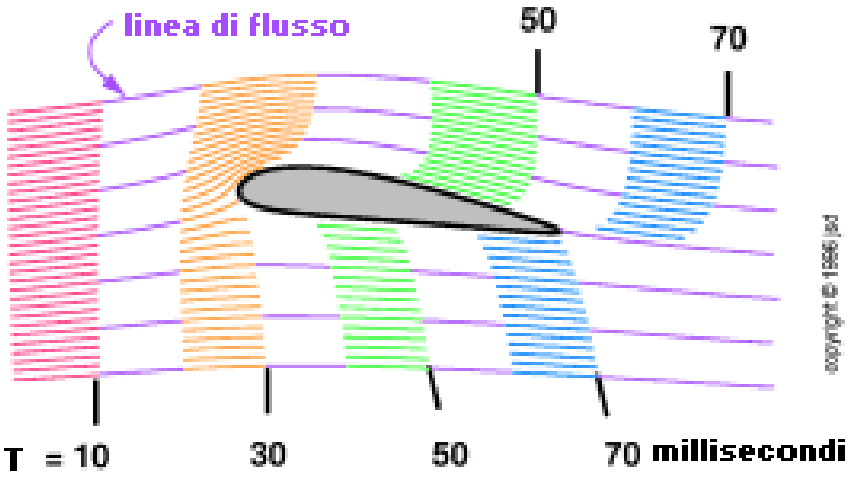
Il vento apparente genera forza propulsiva

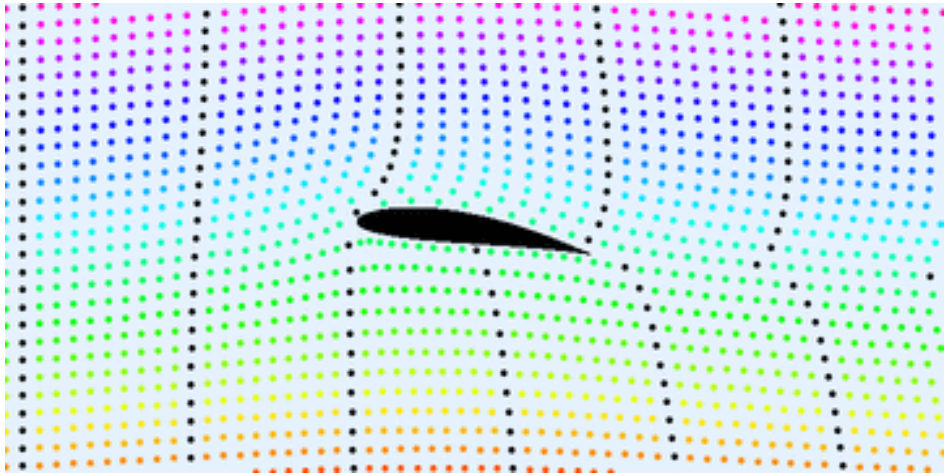
LA VELA È UN'ALA



ALA ESPOSTA AD UN FLUSSO D'ARIA

L'ALA DEVIA IL FLUSSO



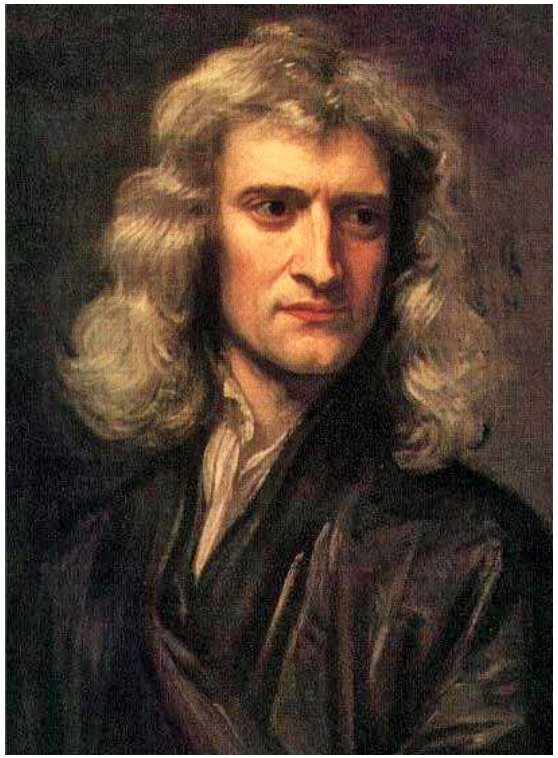


LA PORTANZA (LIFT) PER LA NASA

Lift occurs when a moving flow of gas is turned by a solid object. The flow is turned in one direction, and the lift is generated in the opposite direction, according to Newton's Third Law of action and reaction. Because air is a gas and the molecules are free to move about, any solid surface can deflect a flow. For an aircraft wing, both the upper and lower surfaces contribute to the flow turning. Neglecting the upper surface's part in turning the flow leads to an incorrect theory of lift.

- NIENTE FLUIDO (ARIA), NIENTE PORTANZA
- NIENTE MOVIMENTO, NIENTE PORTANZA

ISAAC NEWTON (1642-1726)



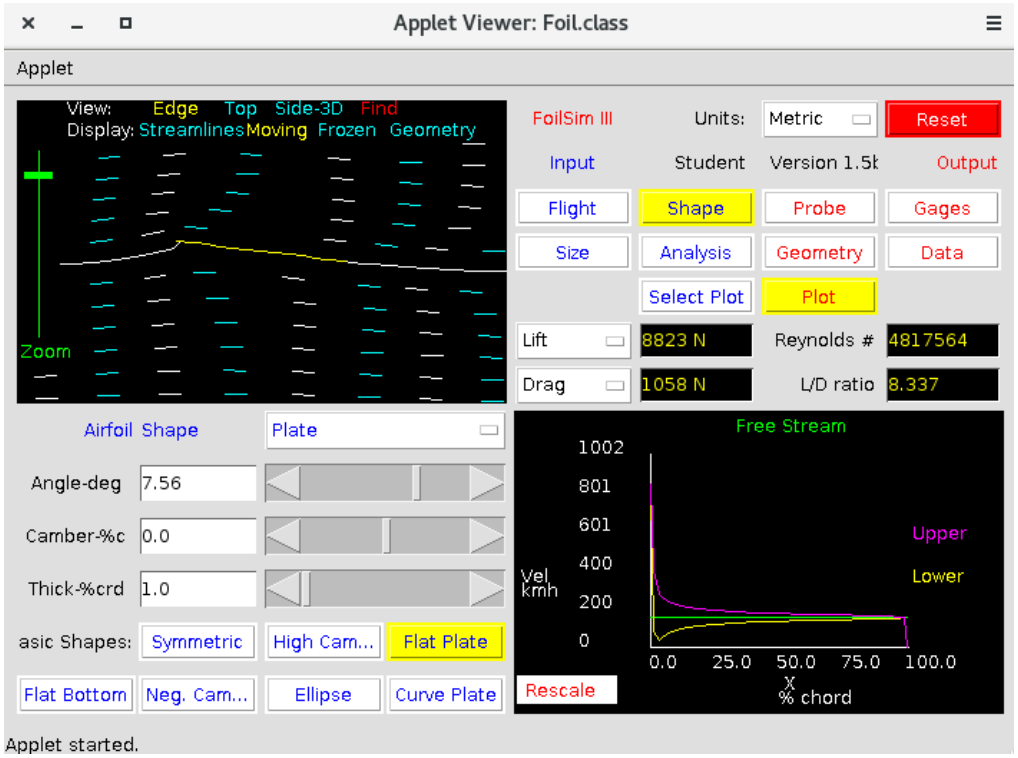
SPOSTARE IL FLUSSO

La portanza è la **forza** generata dallo spostamento del flusso d'aria

$$F = ma = m\frac{(V_1 - V_0)}{t_1 - t_0}$$

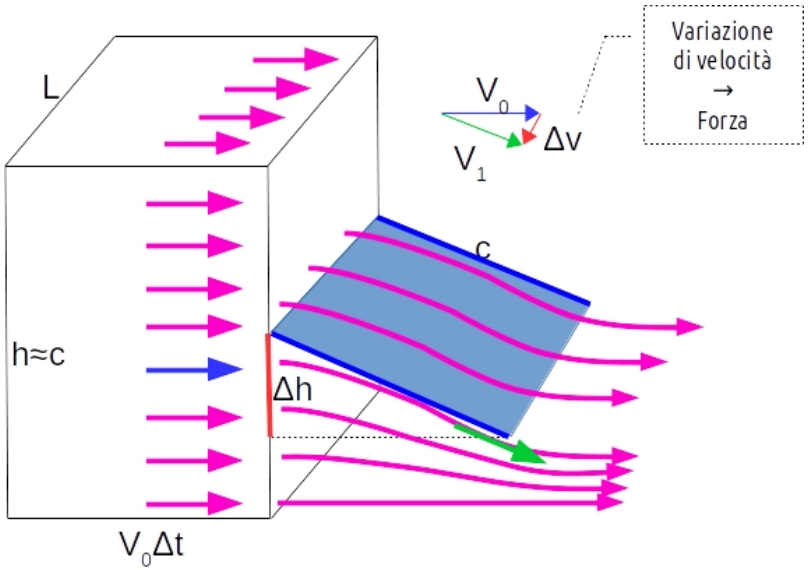
LO ABBIAMO SPERIMENTATO DA PICCOLI

SPERIMENTIAMOLO DA GRANDI ☺



FoilSim by NASA

QUALCHE APPROSSIMAZIONE



Nota che: $\frac{\Delta V}{V} \simeq \frac{\Delta h}{c}$

$$m = \rho \mathrm{Vol} = \rho c L v \Delta t = \rho A v \Delta t$$

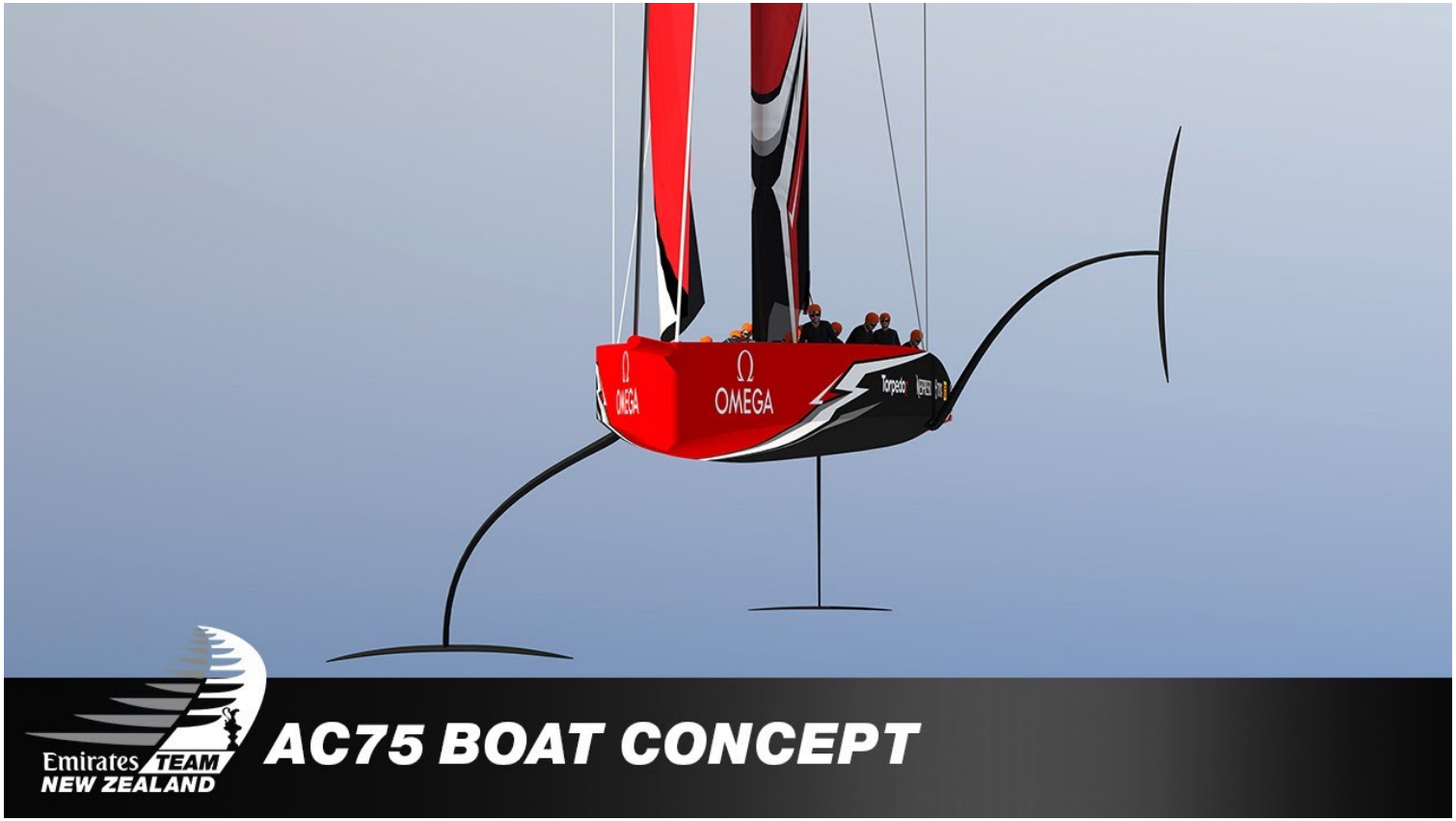
Quindi: $F = ma = m\frac{\Delta V}{\Delta t} \simeq \rho A v \Delta t \frac{\frac{v\Delta h}{c}}{\Delta t} = \rho v^2 A \frac{\Delta h}{c}$

NIENTE MALE

$$F = \rho v^2 A \frac{\Delta h}{c}$$

- ρ è la densita dell'aria
- v^2 è il quadrato della velocità
- A è la superficie dell'ala
- $\frac{\Delta h}{c}$ è l'angolo d'attacco

HYDROFOIL: LA VELA SOTTO!!!



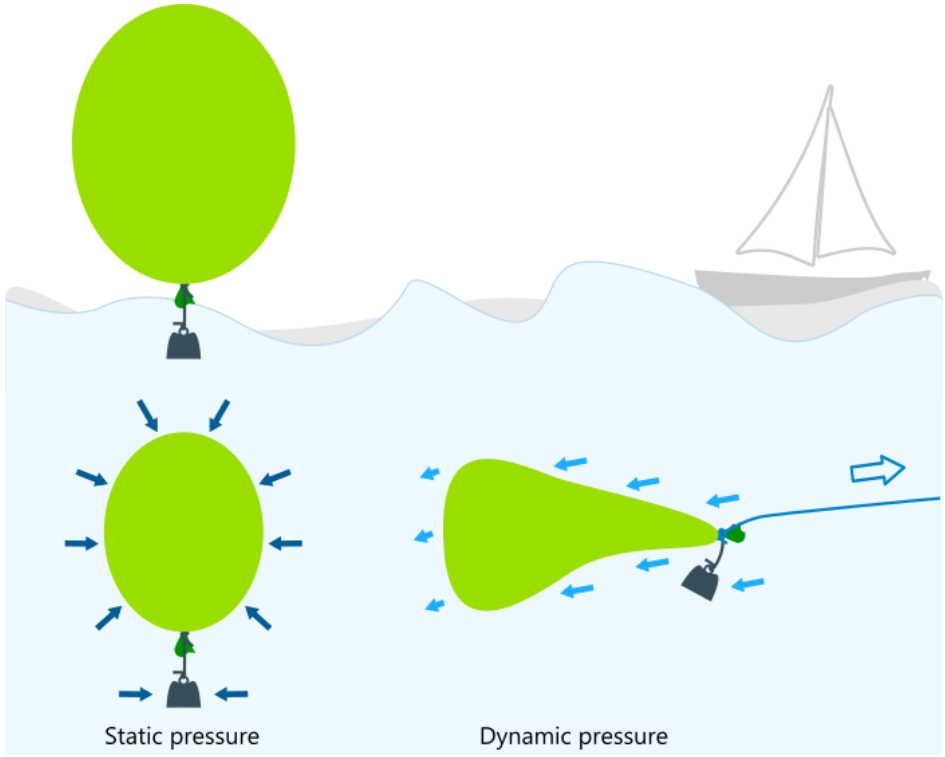
LA DENSITÀ!

$$F = \rho v^2 A \frac{\Delta h}{c}$$

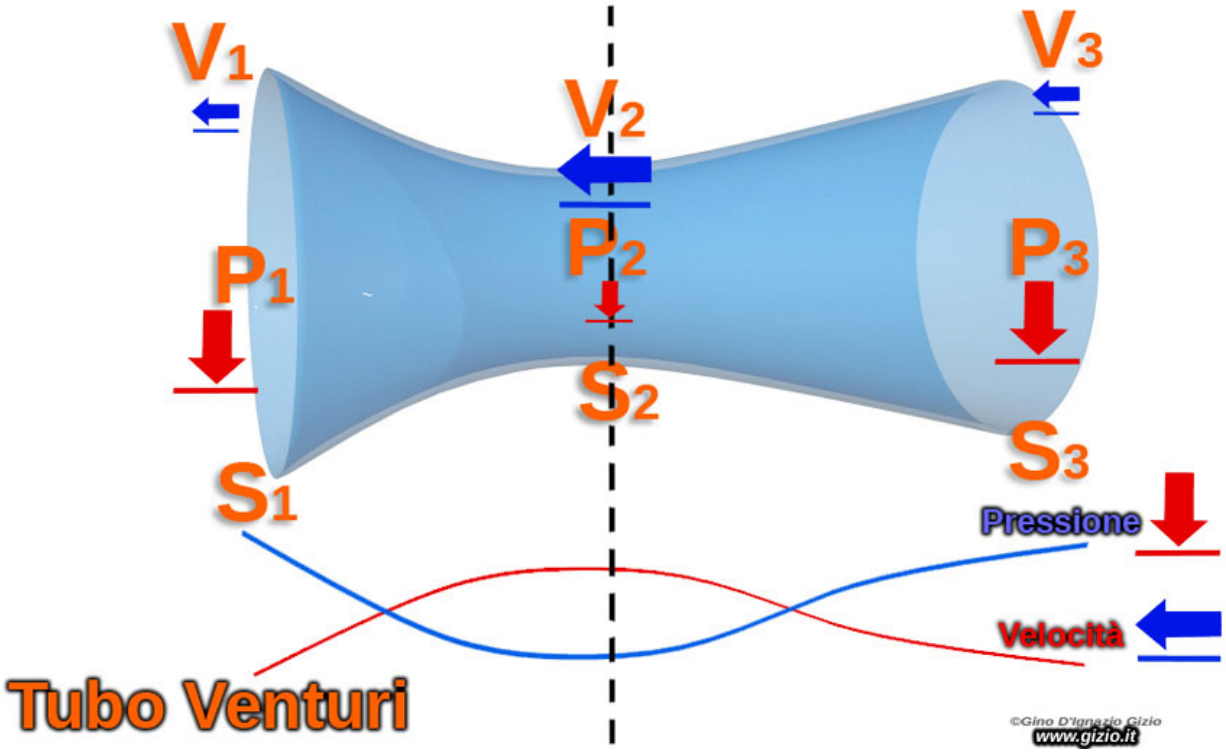
Materiale	Densità (kg/m³)
Abete	700
Acciaio	7860
Acqua a 0 °C	999,8
Acqua a 4 °C	1000
Acqua a 20 °C	998,2
Acqua di mare	1025
Alcool etilico	794
Alluminio	2600-2750
Anidride carbonica	1,98
Argento	10500
Aria	1,293
Basalto	2800-2950
Benzina	700-720
Calcestruzzo	2200-2600
Carta	970
Cenere	900
Cera (paraffina)	950
Cemento Portland	3150
Diamante	3550
Elio	0,179
Ferro	7880
Gesso	2300
Ghiaccio a 0 °C	917
Iridio	22610
Latte a 15 °C	1029-1034
Marmo	2500-2800
Mercurio	13590

DANIEL BERNOULLI (1700-1782)

PRESSIONE STATICA E DINAMICA



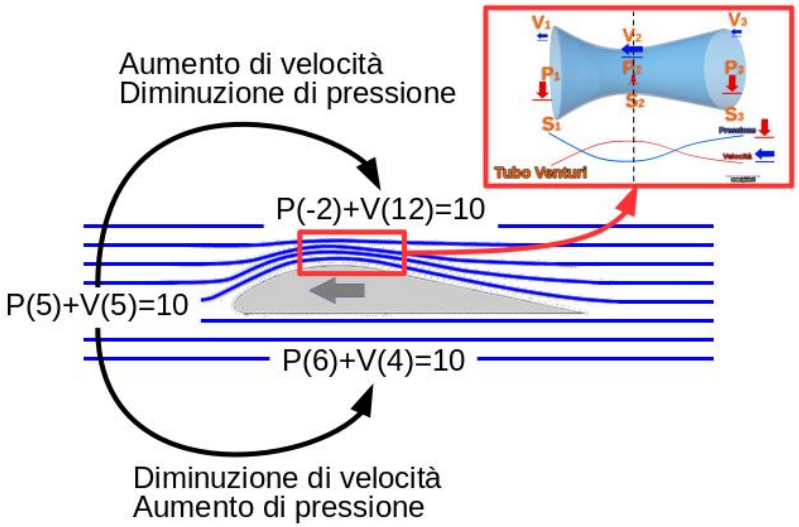
ECCO PERCHÈ!



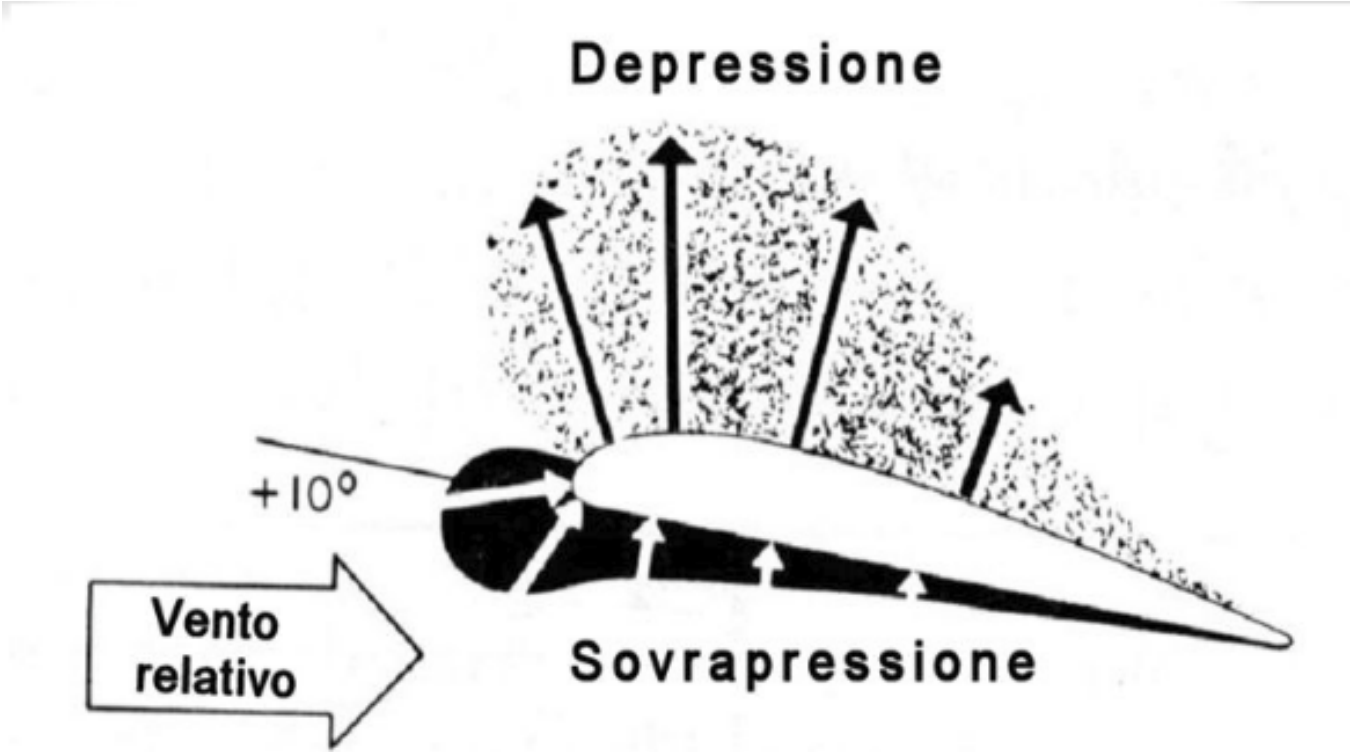
$$p_t = p_s + p_d = costante$$

PROBABILMENTE LO USATE SPESSO!

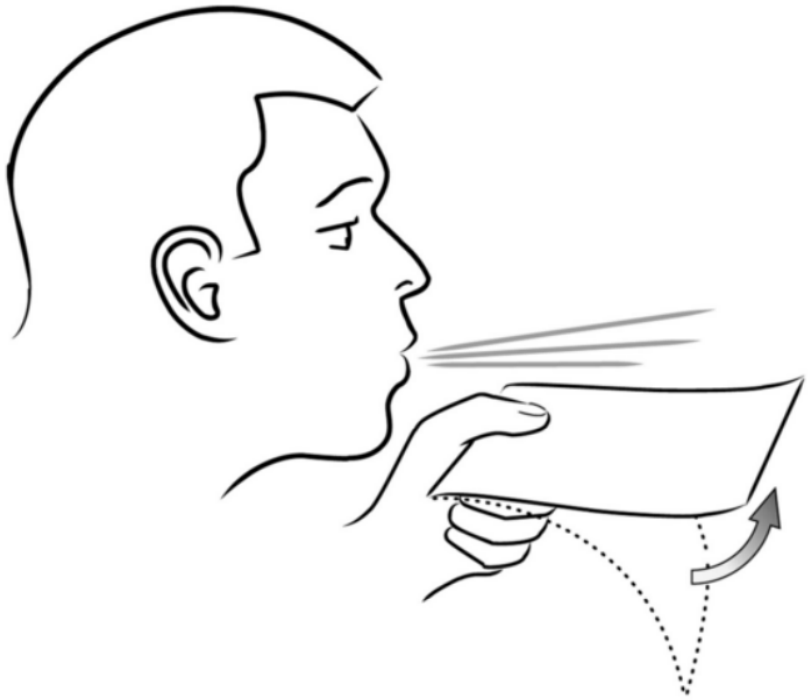
UN SEMPLICE ESEMPIO



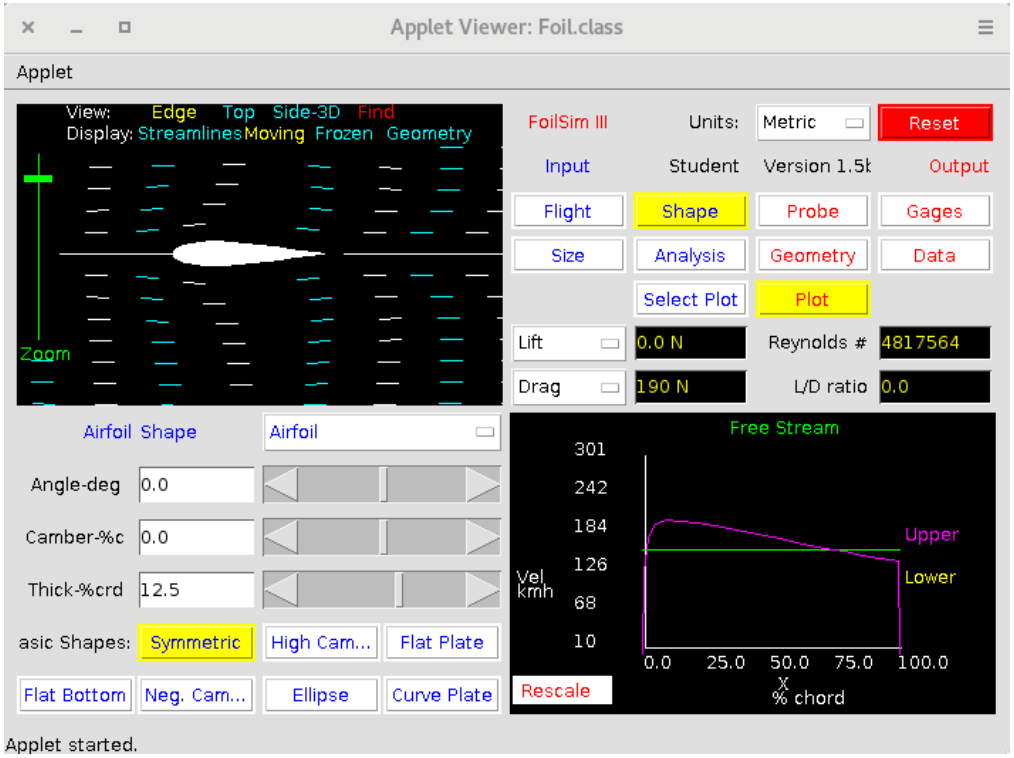
IN SINTESI



GIOCHIAMOCI

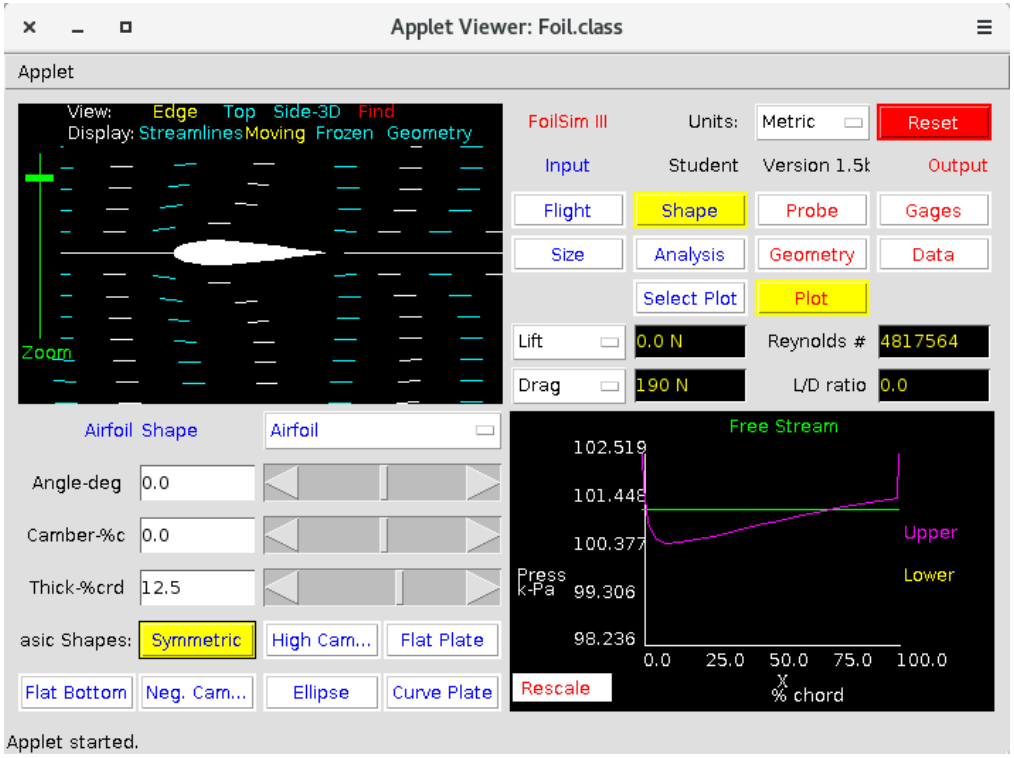


SPERIMENTIAMO



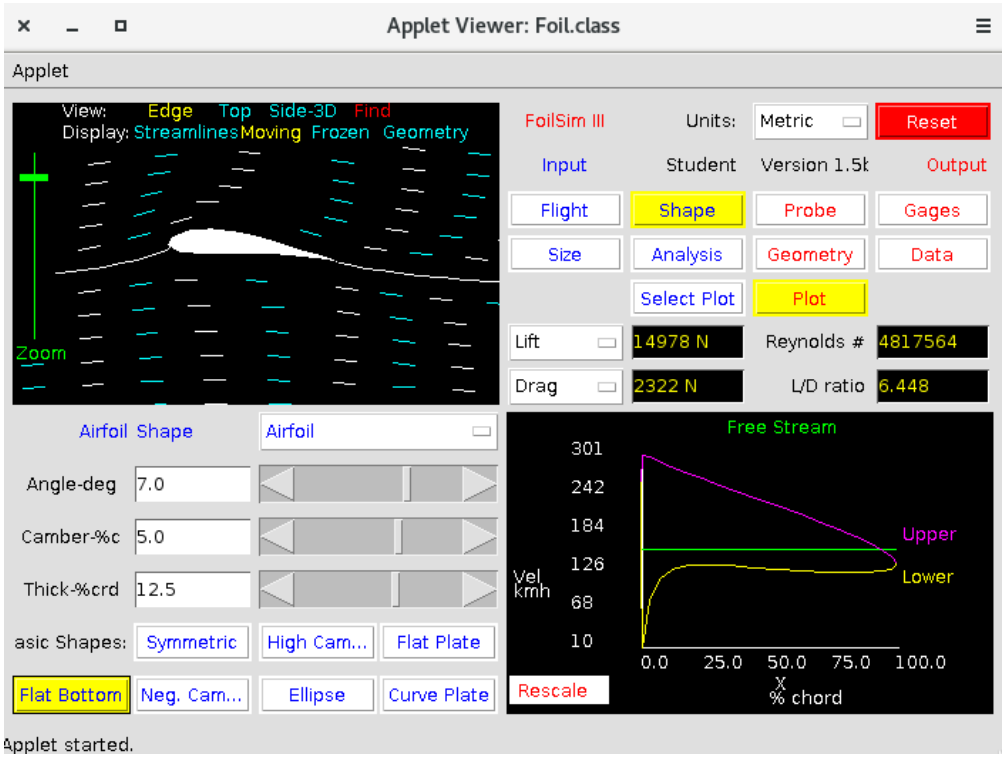
FoilSim by NASA

SPERIMENTIAMO



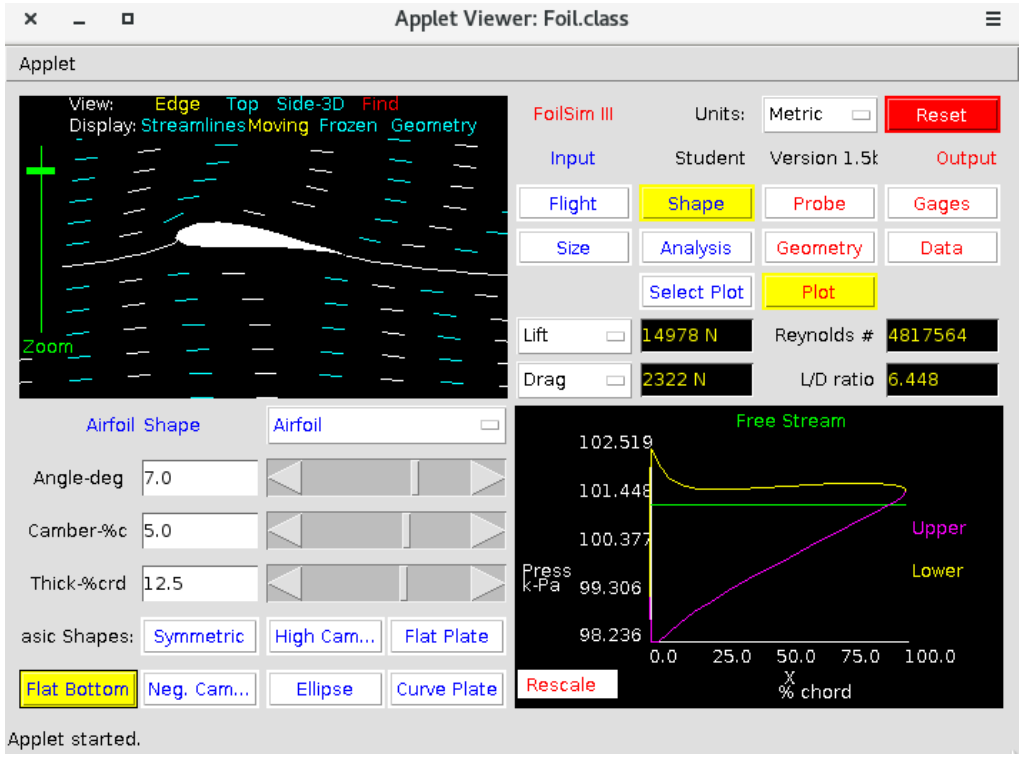
FoilSim by NASA

SPERIMENTIAMO



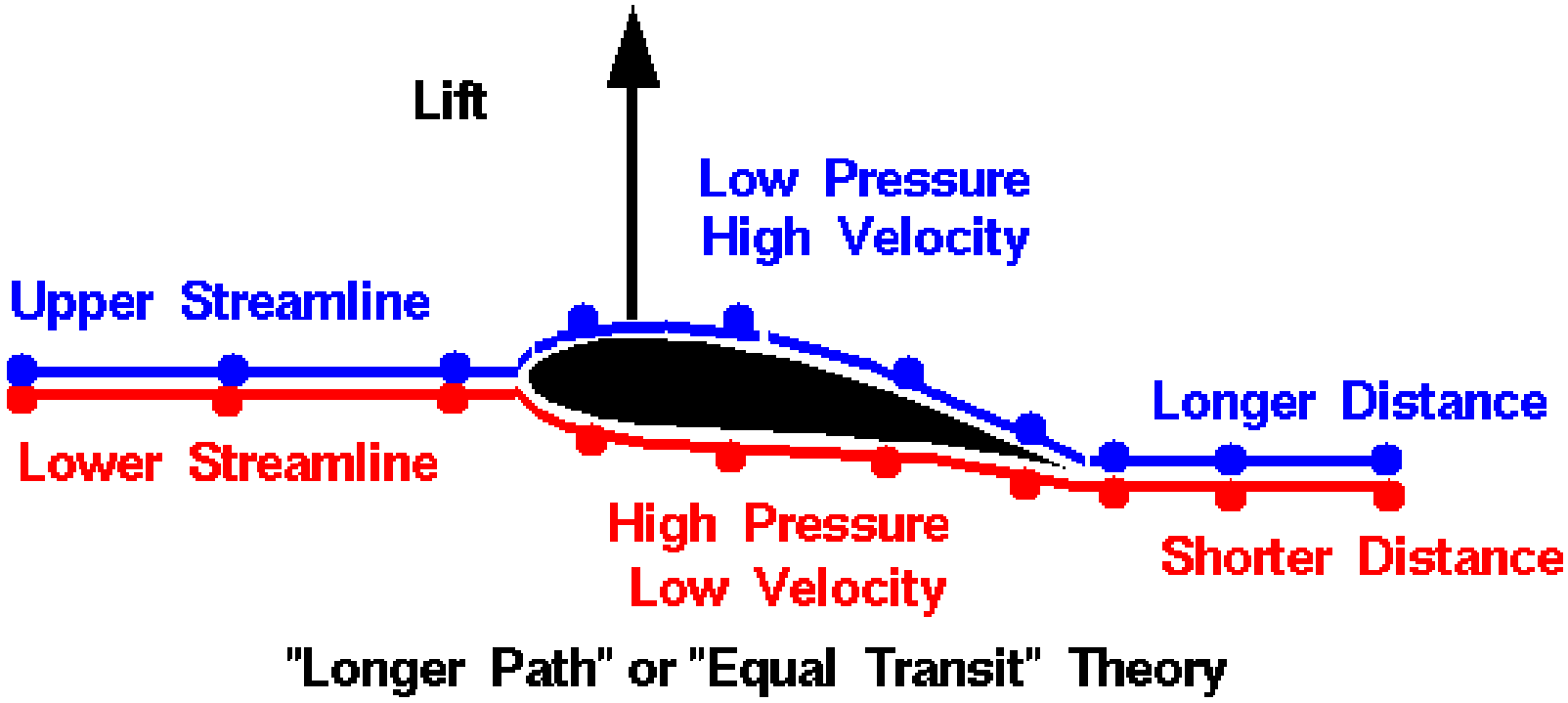
FoilSim by NASA

SPERIMENTIAMO



FoilSim by NASA

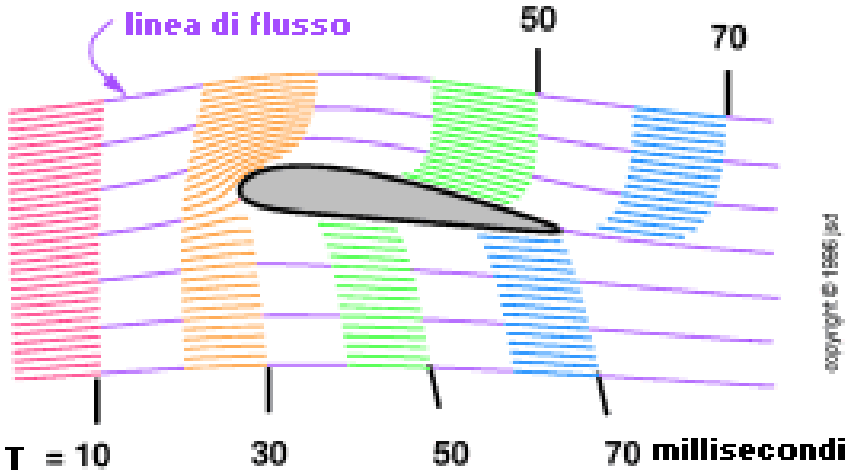
UN ERRORE CONSOLIDATO

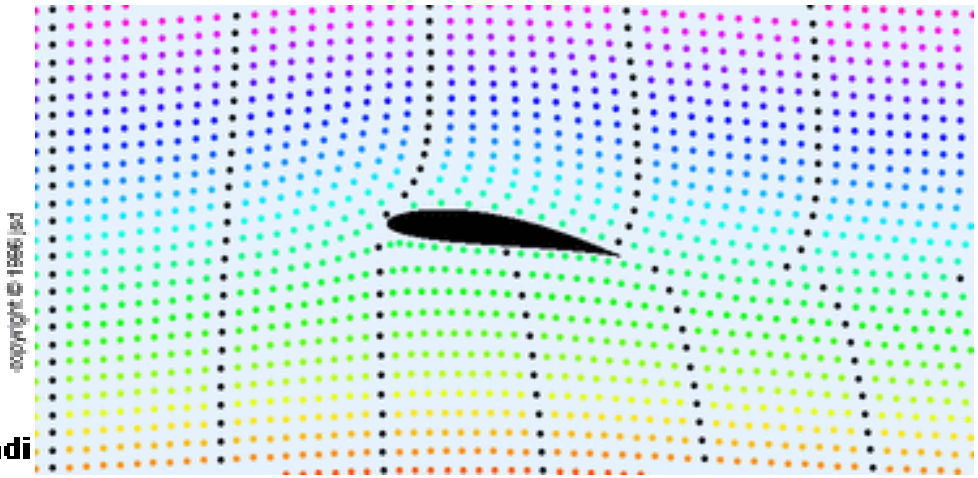


"Longer Path" or "Equal Transit" Theory

SVELIAMO IL MISTERO

I DUE FLUSSI NON ARRIVANO INSIEME!





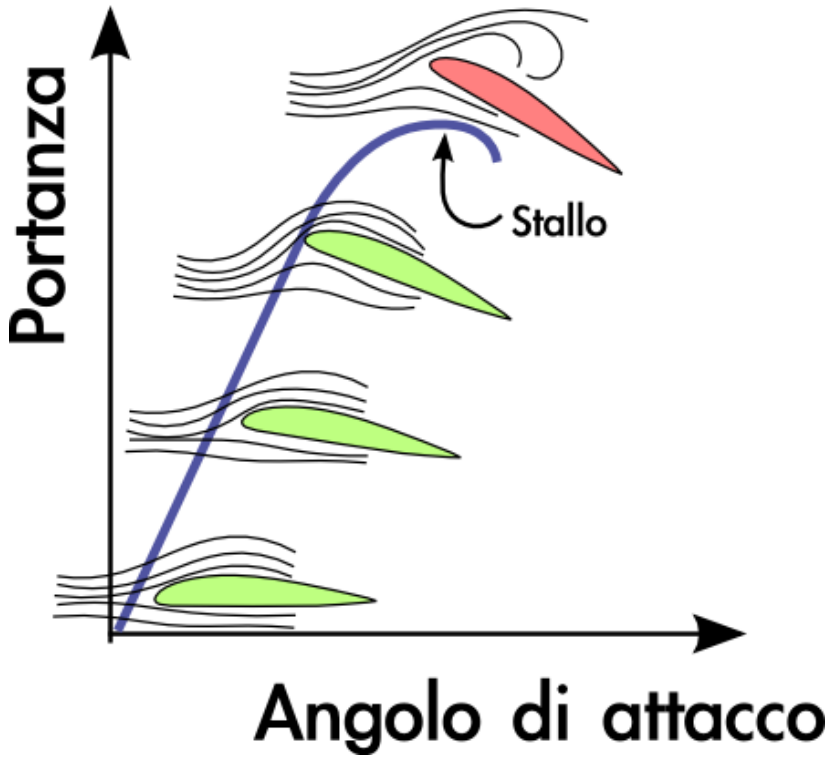
LA REALTÀ È MOLTO COMPLESSA

BASTA BERNOULLI?

DEFINIZIONE DI PORTANZA DELLA NASA

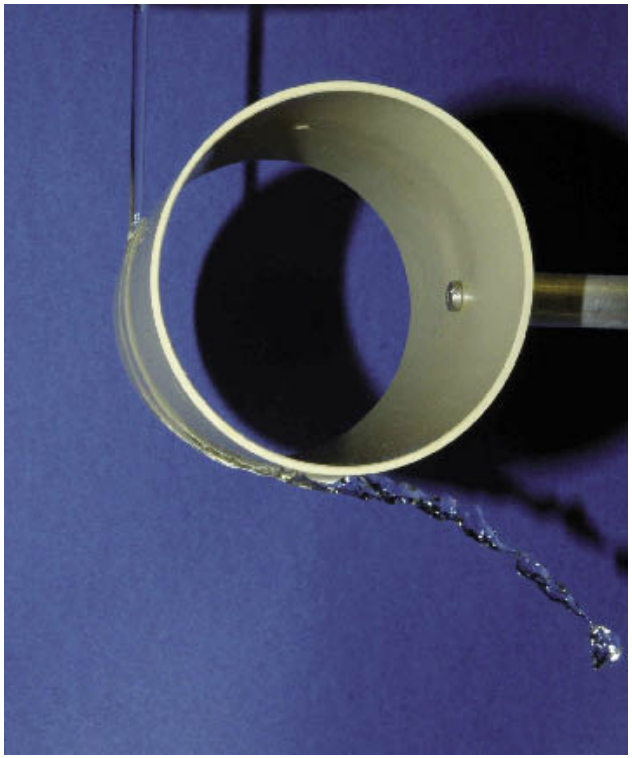
Lift occurs when a moving flow of gas is turned by a solid object. *The flow is turned in one direction, and the lift is generated in the opposite direction, according to Newton's Third Law of action and reaction... any solid surface can deflect a flow. For an aircraft wing, both the upper and lower surfaces contribute to the flow turning. Neglecting the upper surface's part in turning the flow leads to an incorrect theory of lift.*

PORTANZA E ANGOLO DI ATTACCO



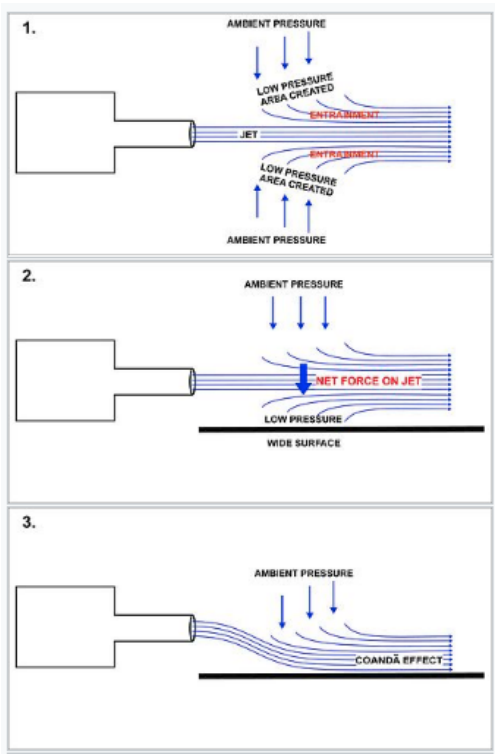
EFFETTO COANDA

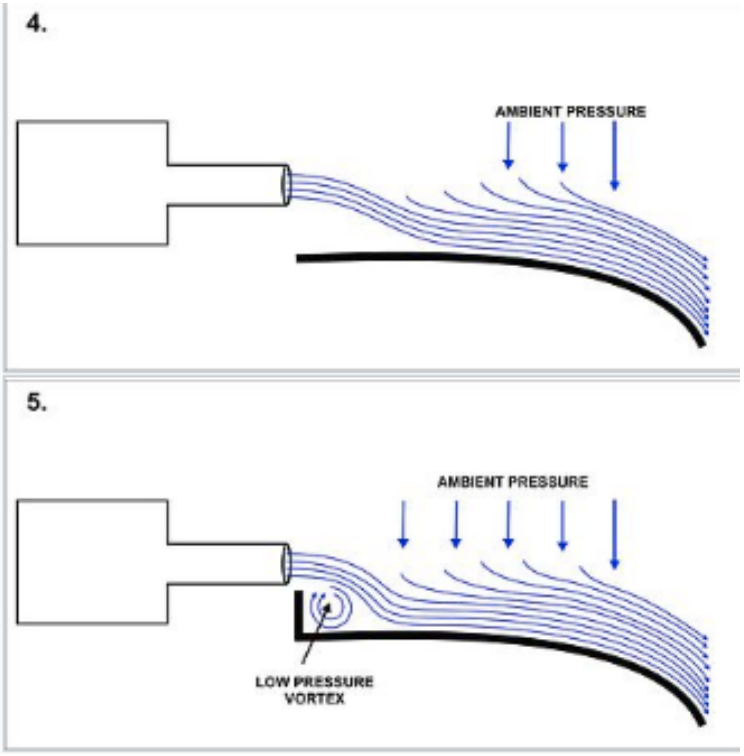
The Coanda Effect Used to Blow Out Candle



HENRY COANDA (1886-1972)

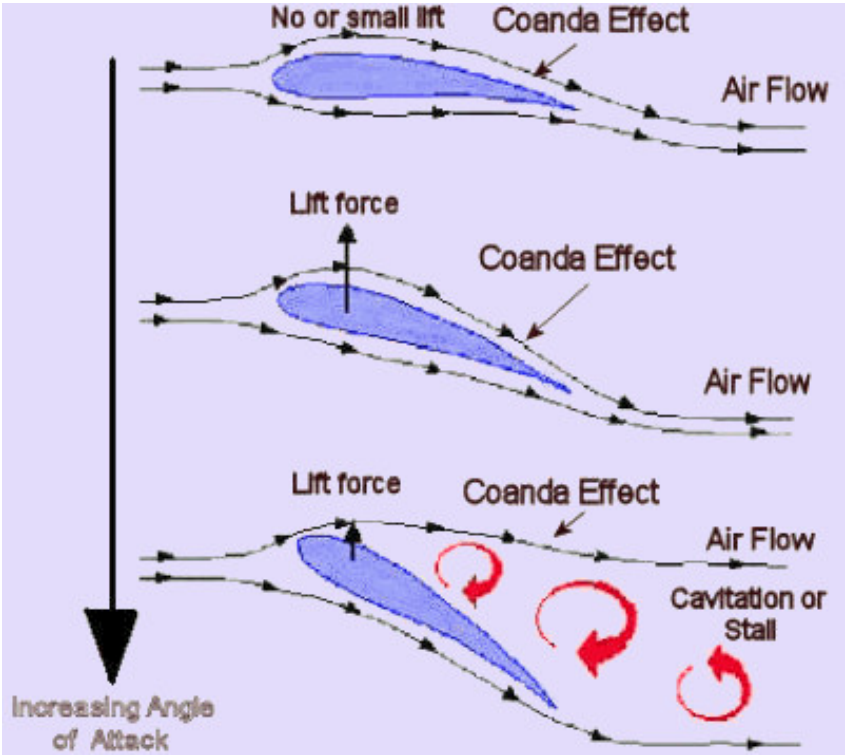
EFFETTO COANDA





EFFETTO COANDA SULL'ALA

... ecco perchè ha un profilo arrotondato!



A QUESTO PUNTO NON RESTA CHE COSTRUIRE UN ALA