

Aerodynamic forces and moments.

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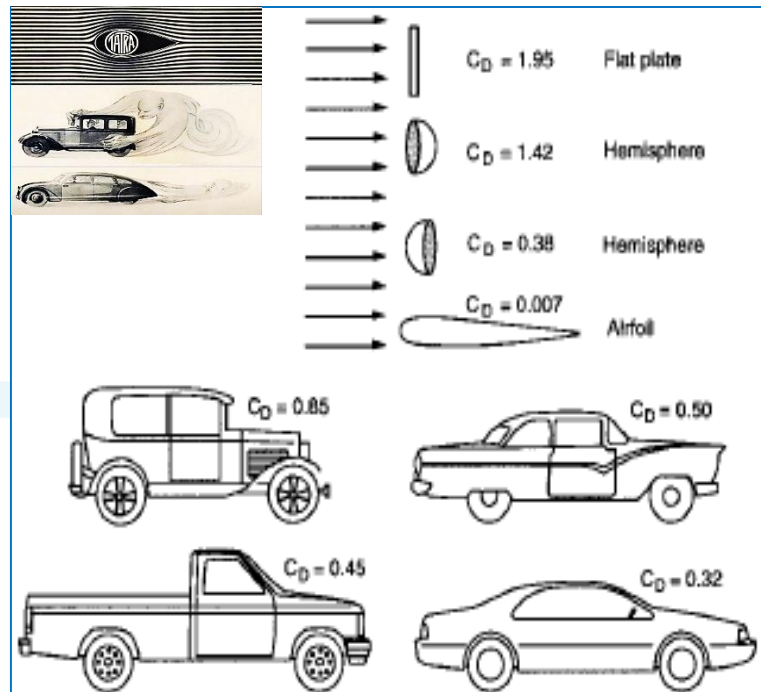
Sustainable Transportation within the Framework of Green Deal - SPHERE

Call: ERASMUS-EDU-2023-CBHE-STRAND-2

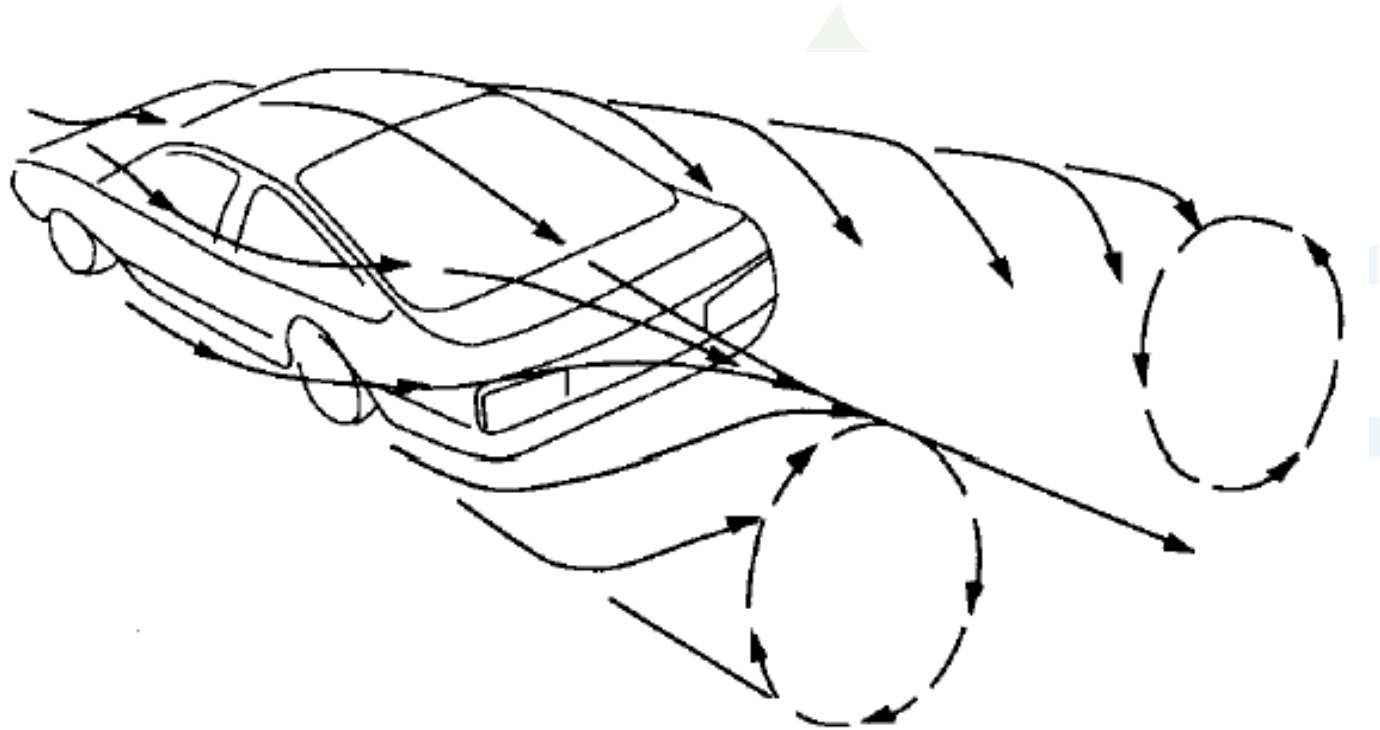
Project Number: 101128065

Shape and aerodynamics

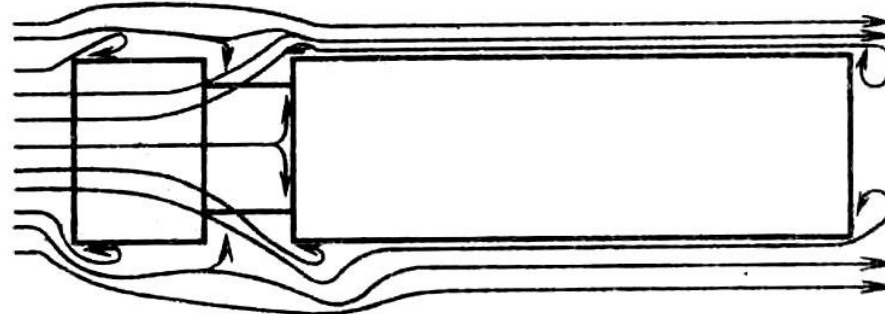
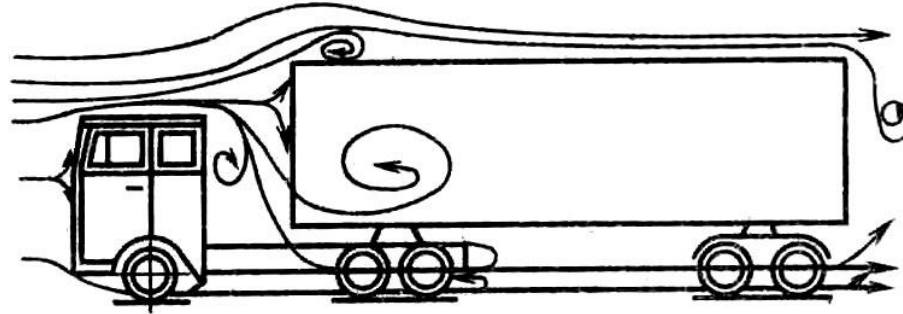
Форма	Описание	Эксперимент
	Куб	1.05
	Куб ребром к потоку	0.8
	Цилиндр торцом к потоку ($h = 2D$)	0.82
	Цилиндр торцом к потоку ($h = D$)	-
	Диск или монета ($4h = D$)	1.15
	Сфера	0.47
	Полусфера	0.38-0.42 по разным источникам
	Полусфера основанием к потоку	1.17-1.33 по разным источникам
	Конус острием к потоку ($2h=d$)	0.5
	Каплевидное тело	0.04



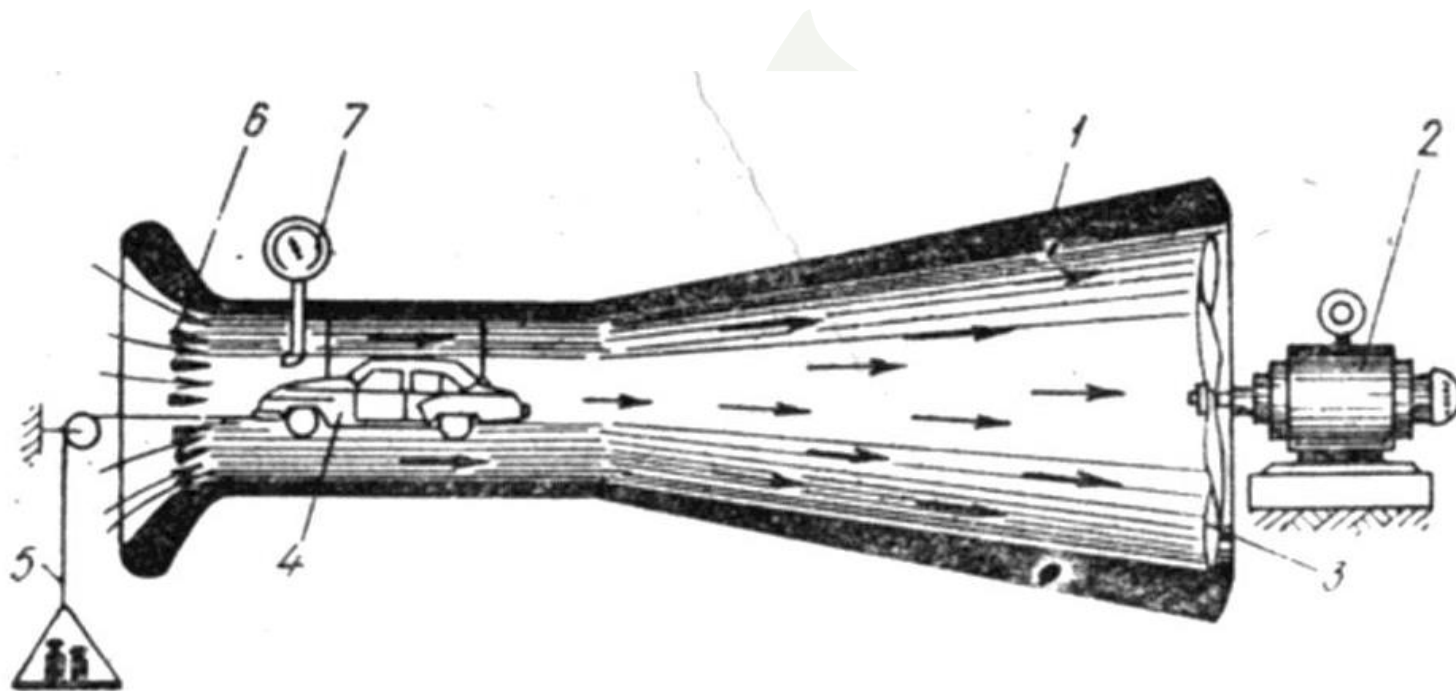
Air flow movement



Directions of air flow in train traffic



Determination of car aerodynamic resistance



There are three main components of aerodynamic drag

- **Form resistance is friction that occurs on the surface of the car body. It depends on the shape of the hull, especially the shape of the rear of the hull. Form resistance is the main weight of aerodynamic resistance (50...60 % R_v).**
- **Frictional resistance - occurs due to the sliding of the cavity along the surface of the body. Usually, such resistance is approximately (5 ... 10 % R_v) of the total air resistance.**
- **The resistance of the flow of cooling, ventilation air passing through the hood and interior of the car. This resistance depends on the construction of the channels through which the air flow passes, and is a few percent of the total air resistance (10...15 % R_v).**

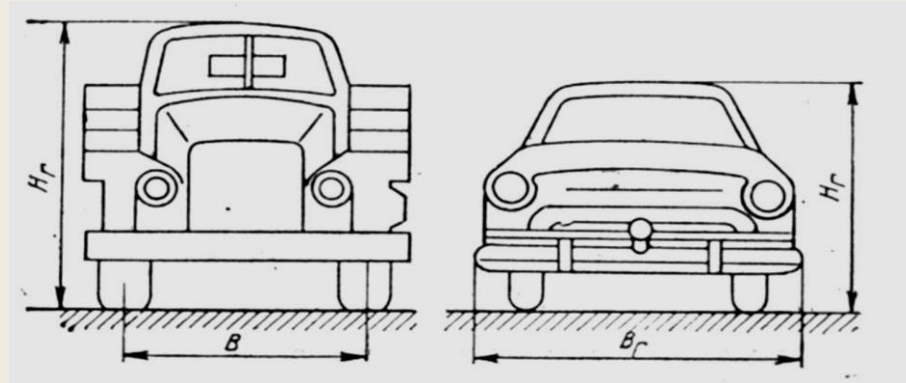
The air resistance force – P_w can be divided into several components

- *Form drag {(50...60 % R_v) resistance caused by high pressure in front of the car and low pressure behind the body.*
- *(methods for controlling form drag - spoiler)*
- *Internal drag {(10...15 % R_v), resistance caused by air flow inside the car cabin, air resistance passing through the engine cooling system*
- *Surface sliding drag {(5 ... 10 % R_v), resistance caused by friction of the air flow on the surface of the car.*
- *(method for reducing friction drag, at high speeds?) Air flow on an edged surface; Air flow on a needle-shaped surface; Flow on the surface of a dolphin's body. (diagram and graphs $P_w=f(V_a)$)*
- *Inductive resistance {(5.. 10% P_β), resistance caused by air forces acting on the longitudinal and transverse axes of the car*
- *Additional resistances {(15% P_β), air resistance caused by protruding parts on the surface of the car (headlights, rear-view mirrors, various externally installed signs, ...)*

An approximate calculation for determining the force of air resistance

The coefficient of air resistance - $k = (0.5 \times \rho v)$ can be considered to depend only on the shape of the body.

$$P_w = 0,5c_x \rho_v F v_a^2 = k F v_a^2$$



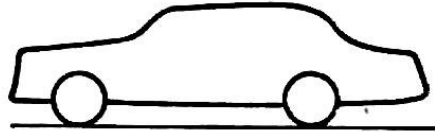
Air resistance coefficients of light vehicles



$C_D = 0,311$
a)



$C_D = 0,38$
b)



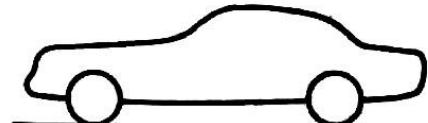
$C_D = 0,387$
c)



$C_D = 0,416$
d)

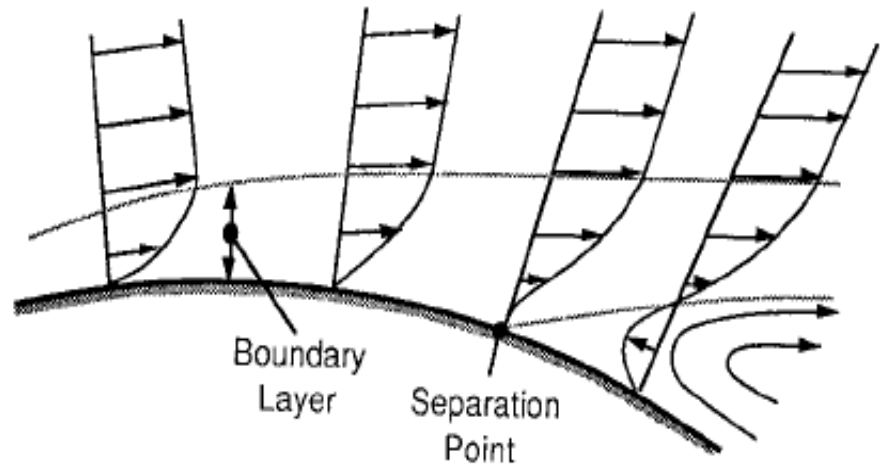
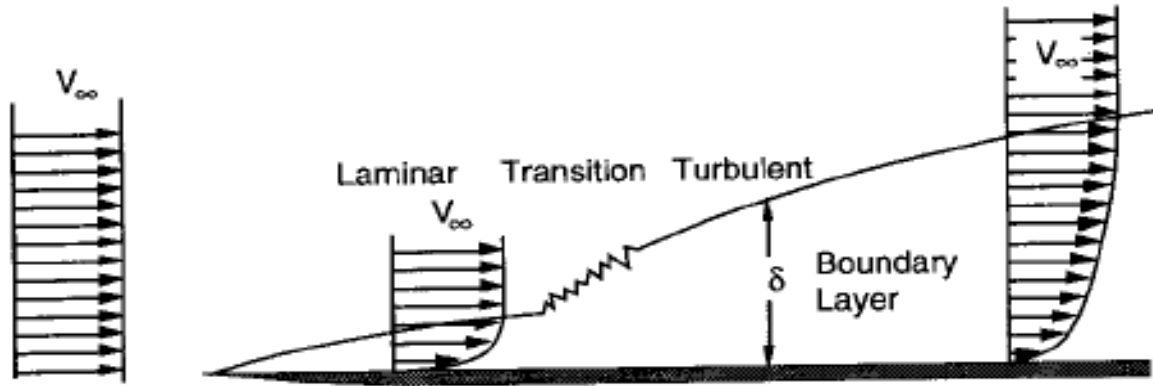


$C_D = 0,458$
e)

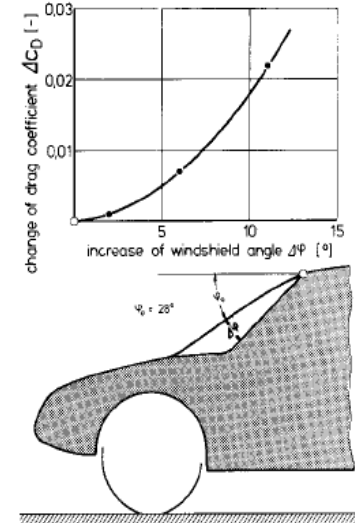
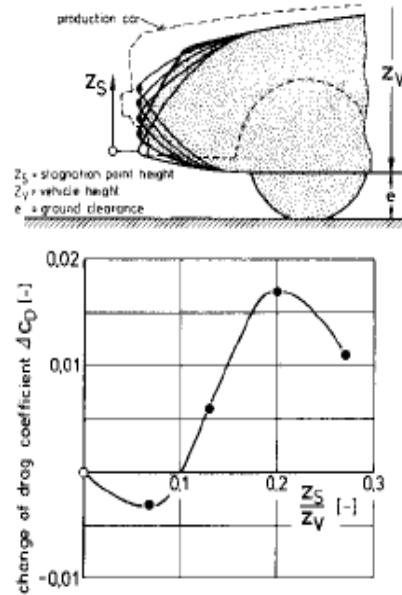


$C_D = 0,475$
f)

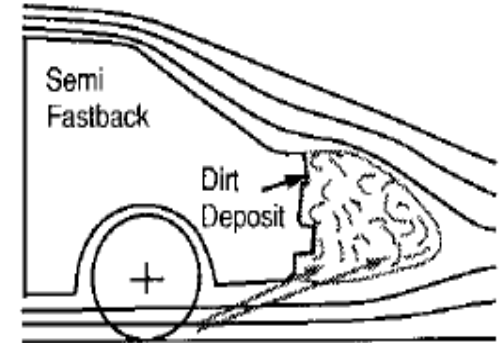
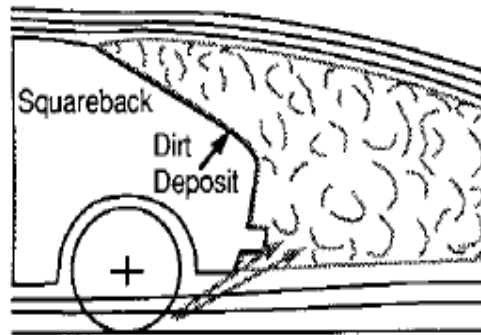
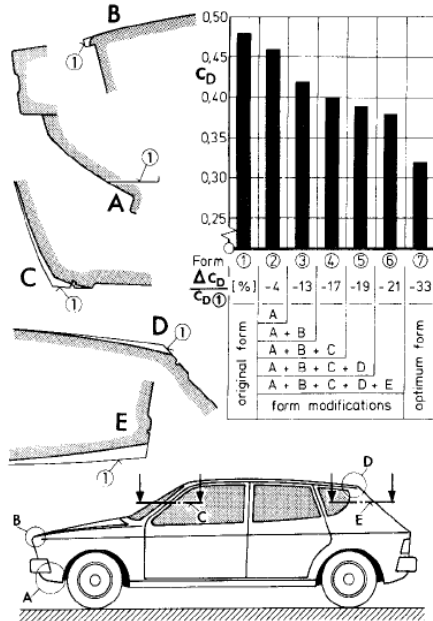
Surface air flow



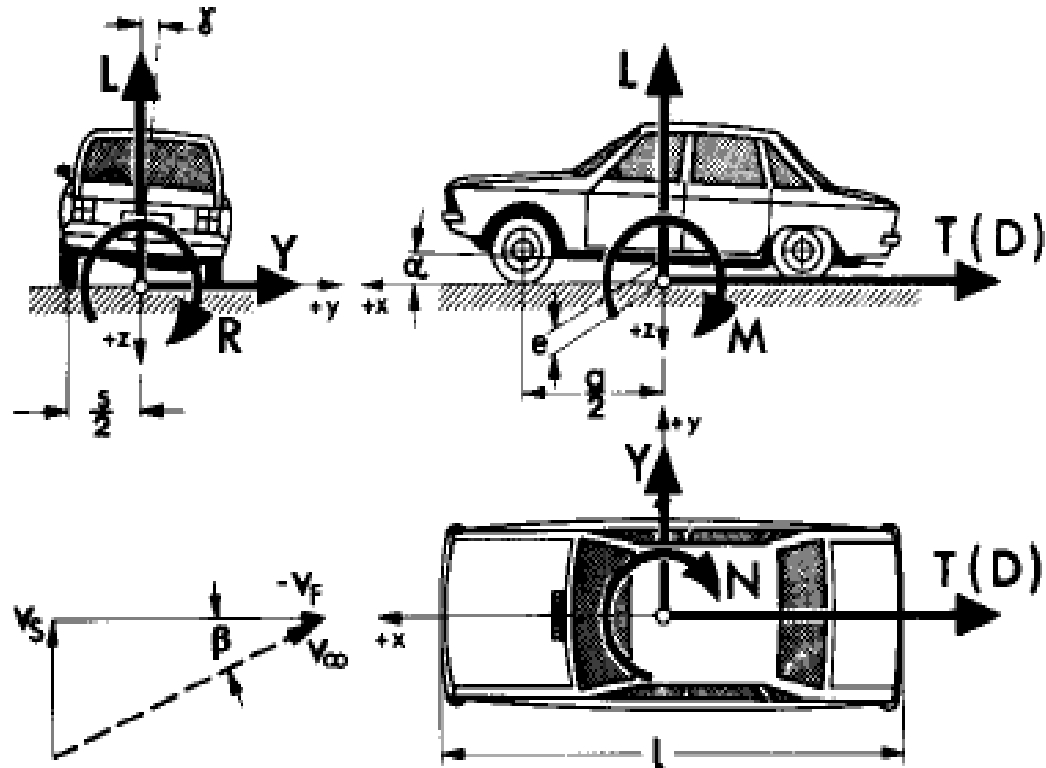
The effect of the front surface and design of the car on the coefficient



Optimizing bodywork details



Aerodynamic forces and moments



Thank you for your attention!

