**12th December 2019. THURSDAY 18:15h-19:45h (K155) RETAKE**
**BMEGEÁTMW19 Aerodynamics and Its Application for Vehicles**
available time: **90 min**. (lecturer: Dr. JM Suda)

NAME:……Signature:…… NEPTUN code:……

**PLEASE READ CAREFULLY THE QUESTIONS! TAKE CARE OF YOUR HANDWRITING!**

**GIVE YOUR ANSWER IN A SHORT & CLEAR FORMAT! TRY TO POINT TO THE MAIN ESSENTIALS ONLY! USE SKETCHES IF NEEDED! pen/pencil can be used**

**THERE IS ENOUGH FREE SPACE LEFT for your SHORT/DENSE answers!**

| QUESTION TOPIC | max. points | achieved score |
|---|---|---|
| **HISTORY** | | |
| **1.** | **10** | |
| **2.** | **10** | |
| **BASICs** | | |
| **3.** | **10** | |
| **4.** | **10** | |
| **5.** | **10** | |
| **PASSENGER CARS** | | |
| **6. (calculation!)** | **20!** | |
| **7.** | **10** | |
| **8.** | **10** | |
| **9.** | **10** | |
| **+Additional question** | **+10** | |
| **RESULT** | Σ100 | Σ…… =……% |

# 1)HISTORY

**Fill in the table below with the <u>names</u> of the four main periods of aerodynamic developments and indicate their approximate <u>time intervals</u>, too!**

| PERIODs | NAME of the PERIOD | time interval (from - to): (approx. year/decade) |
|---|---|---|
| I. | | |
| II. | | |
| III. | | |
| IV. | | |

**The "*La Jamais Contente*" (="The Never Satisfied") was the first automobile to break the 100km/h (62 mph) record, in 1899.**
**<u>List and explain the aerodynamic disadvantages of this vehicle!</u>**

**<u>List few other famous vehicles from the same period!</u>**

# 2)HISTORY


**Pál (Paul) Járay** is the most famous aerodynamicists of the 2nd period in the history of aerodynamic developments.

**A) Sketch his idea of "combined form" and explain why was it revolutionary in vehicle aerodynamics!**

**B) Name some known vehicles that are based on Járay's idea!**

# 3)BASICS

The F aerodynamic force acting on a vehicle is defined as being the sum of the $\underline{F_p}$ pressure based force term and the $\underline{F_f'}$ viscous force term:

$$\underline{F} = \underline{F_p} + \underline{F_f'}$$

**Derive / transform this equation with short explanations on the main steps of derivation! Please show how the pressure coefficient and the wall (skin) friction coefficient and the reference parameters (velocity, ambient pressure and fluid density) are included!**

The final form of the equation that contains both the pressure coefficient and skin friction coefficient:

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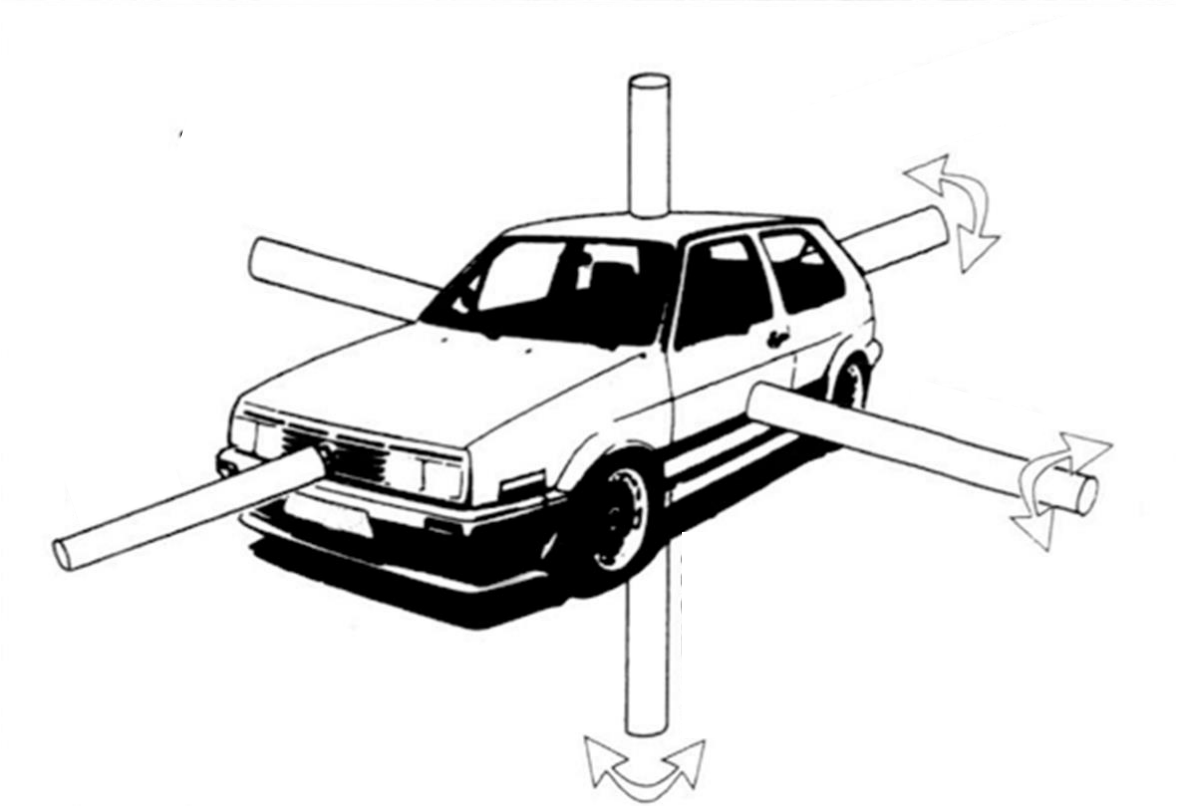
**Define the $c_p$ pressure coefficient and the $c_f$' wall friction coefficient with their formula and indicate their range, magnitude, min/max. limits, if any!**

| pressure coefficient<br><br>$C_p =$ | wall (skin) friction coefficient<br><br>$C_f' =$ |
|---|---|
| range, magnitude, min/max limit values: | range, magnitude, min/max limit values: |
| | |

# 4)BASICS

Define the coordinate system: denote the axes (x;y;z) in the figure below!
Define in the figure the aerodynamic force and moment components!
Define also in the figure the $A_{ref}$ projected frontal area,
Indicate the $v_\infty$ incident flow velocity vector, too!



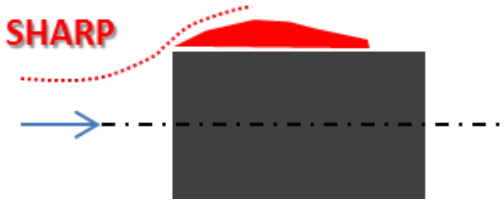
Define in the table below the **drag, lift & side force components** with their formula that contains the force coefficients!

| drag force | side (yaw) force | lift force |
|---|---|---|
| $F_D=$ | $F_{S(Y)}=$ | $F_L=$ |

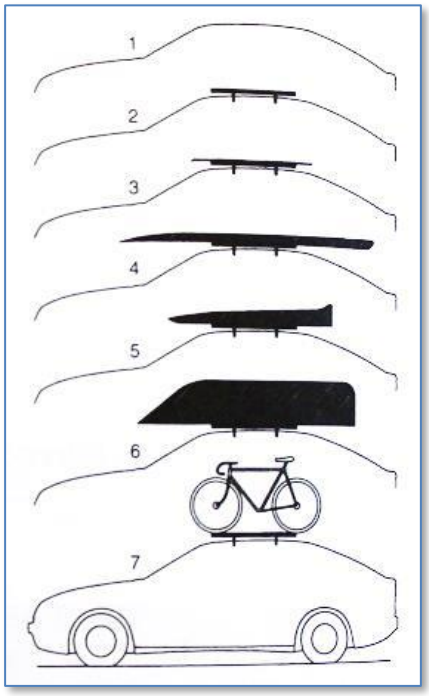
# 5)BASICS

In case of a **prismatic bluff body** what are the main consequences of the ground proximity? (pressure coefficient distribution, drag and lift force, coefficients, analyse also the pressure coefficient distribution on the front & rear, sides, top & underbody surfaces!

List some further solutions (except rounding-up the front) for drag reduction of sharp front edges!



# 6)PASSENGER CARS




Let's consider a passenger car with max engine power of $P_{max}$**=100kW**. The top speed of this car is $v_{max}$**=198km/h** in still ambient ($\rho_{air}$**=1,2kg/m$^3$**). The vehicle's projected frontal area is $A_{proj,ref}$**=2m$^2$**. The force coefficients are known: $c_D$**=0,34** and $c_L$**=0,28**.

**QUESTIONS:**

**A)** Calculate the drag and lift forces! **$F_D$=? [N]; $F_L$=? [N]**

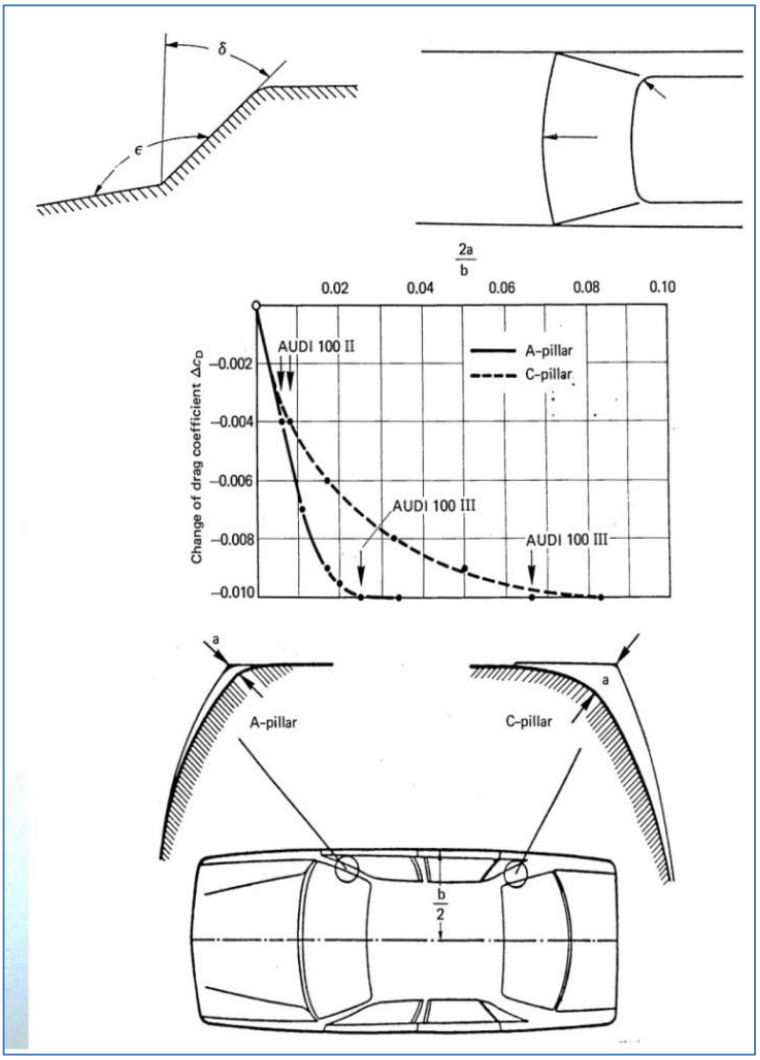
**B)** Calculate the aerodynamic power loss **$P_{ae}$=? [W]**

**C)** A boot (see in Fig. Nr.7.) is placed on the roof rack. The projected reference area increases by $\Delta A_{proj,ref}$**=+0,4m$^2$**, and the drag coefficient increases by $\Delta c_D$**=+0,21**. When driving the car with the boot on the top we experience that the top speed of the vehicle is changed. We can assume, that the aerodynamic power loss is the same for cases with and without the boot. Calculate the modified top velocity! **$v_{max,mod}$=? [km/h]**

**6) cont.**

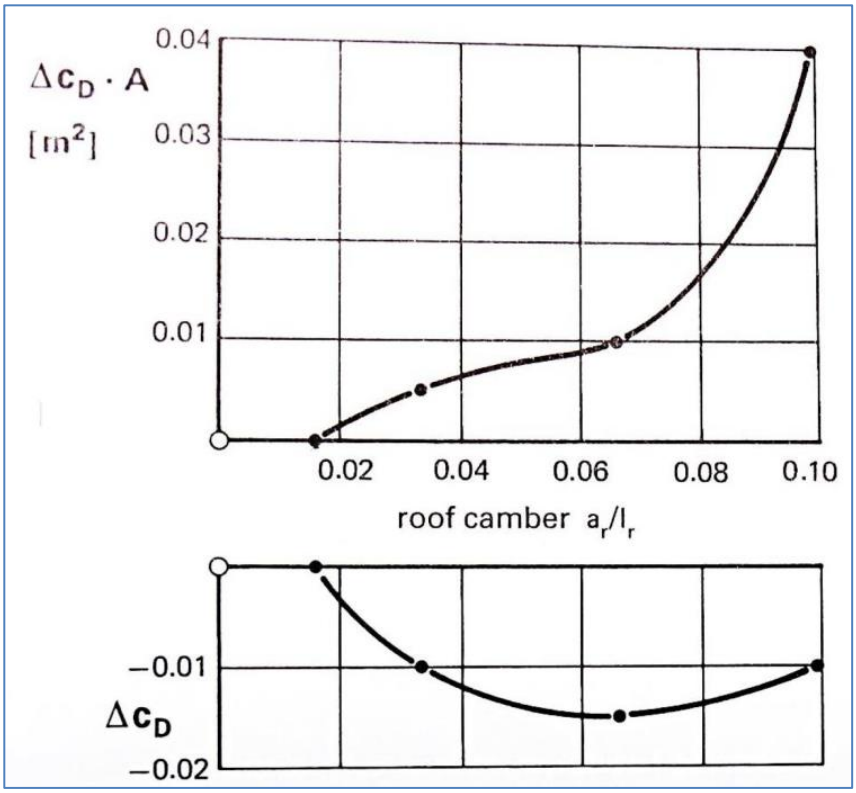
# 7)PASSENGER CARS

**Analyse the influence of the rounding-up of the A-pillar on drag and lift**!



# 8)PASSENGER CARS

**With the help of the diagrams give an explanation on the advantages & disadvantages of the roof cambering!**



## 9)PASSENGER CARS

Give explanation for the fact that higher W wheel width results in increased drag and lift coefficients!

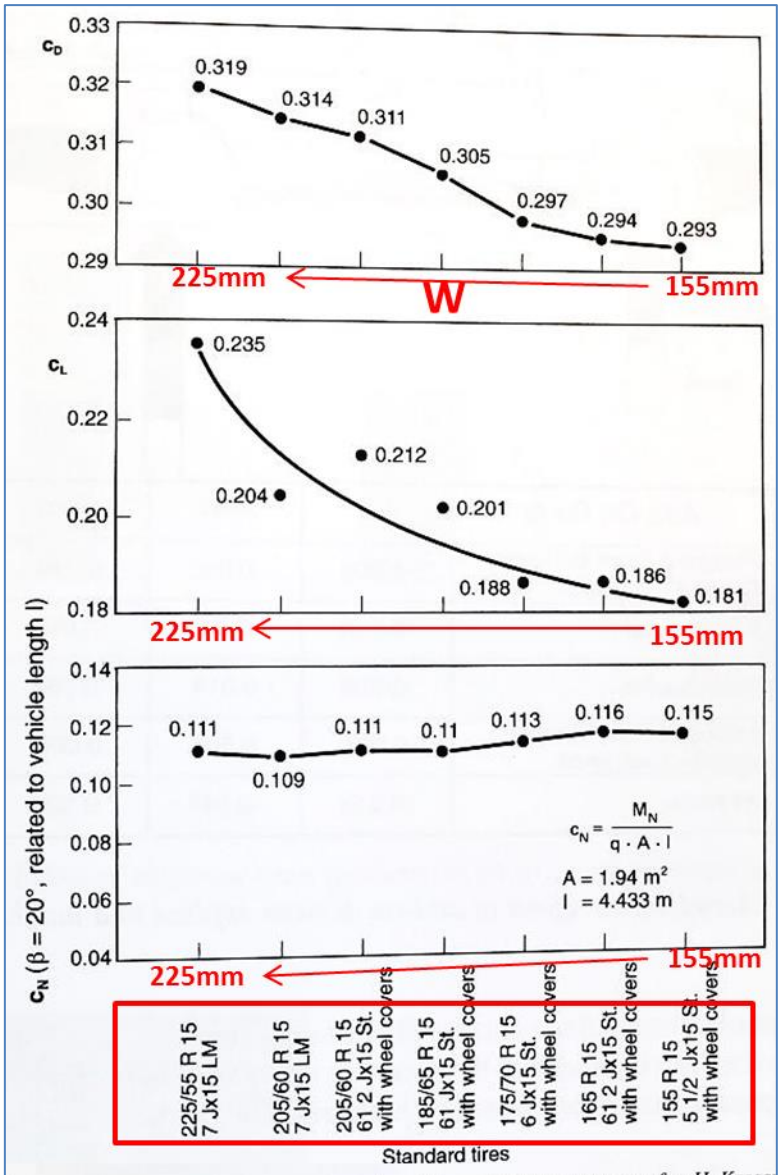



*Fig. 5.72 Influence of the tire width on drag, lift, and yawing moment, after H. KERSCH*

## ADDITIONAL QUESTION (+10point)

**A)**Analyse the diagram below: there are several „peak” points of the top side pressure distribution.

Give explanation for each local maximum and minimum pressure locations!

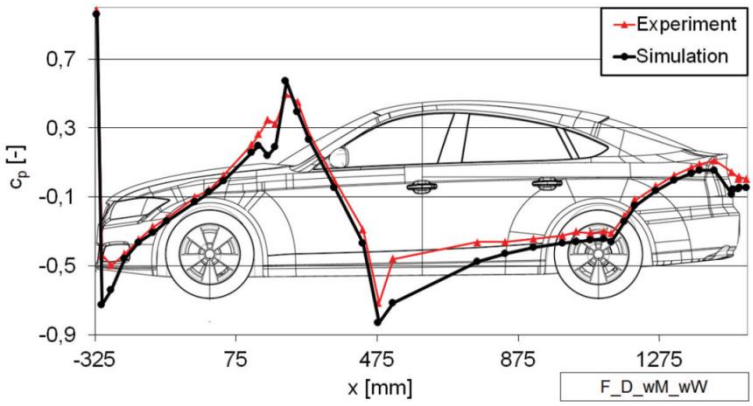



**FIGURE 10**. DISTRIBUTION OF THE PRESSURE COEFFICIENT IN THE SYMMETRY PLANE AT THE TOP OF THE VEHICLE (F_D_wM_wW).

**B)**Which is aerodynamically favourable case here: the streamwise positive or the streamwise negative pressure gradient? Explain your answer!