Department of Automotive Technologies –
Vehicle Mechanics Fundamentals

Gábor Sipos

Lecture 5

Schedule

DEPARTMENT OF AUTOMOTIVE TECHNOLOGIES

Week nr.	Date	Lecture (Wednesday)		Lab (Wednesday)	
1	12th Feb	1	General information, Tyre, Driving force	1	Lab
2	19th Feb	2	Longitudinal and lateral behaviour		
3	26th Feb	3	Concepts and over/understeer	2	Lab
4	5th Mar	4	Weight transfer		
5	12th Mar	5	Bicycle model	3	Lab
6	19th Mar	T1	Midterm exam I.		
7	26th Mar	6	Braking and brakes	T1 R	Exam 1 - replacement
8	2nd Apr	-	Systems of the vehicle		
9	9th Apr	7	Break		Break
10	16th Apr	8	Quarter vehicle model		
-	23th Apr		Break		Break
11	30th Apr	T2	Systems of vehicle II. ONLINE	4	Lab
12	7th May	9	Tyre management		
13	14th May	10	Midterm exam II.	11	Racecar engineering
14	21st May	T2 R	Exam 2 - replacement		

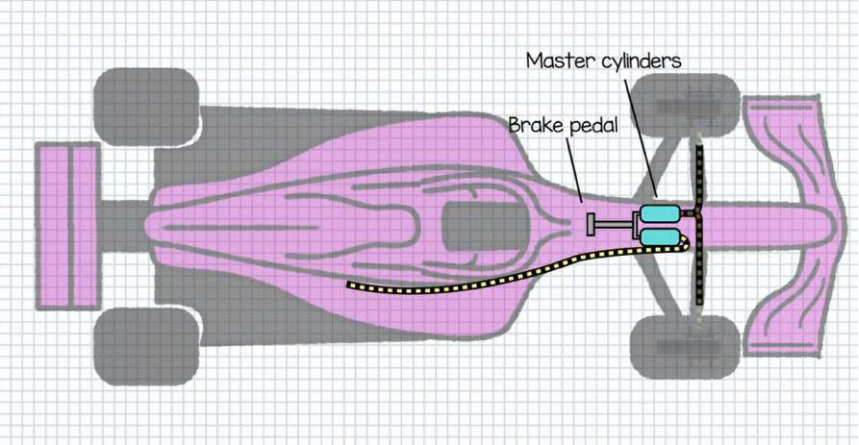
Braking video

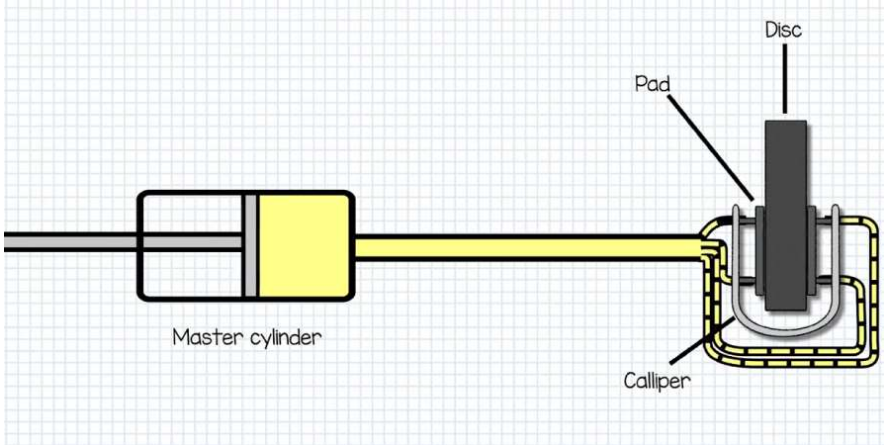
Braking video

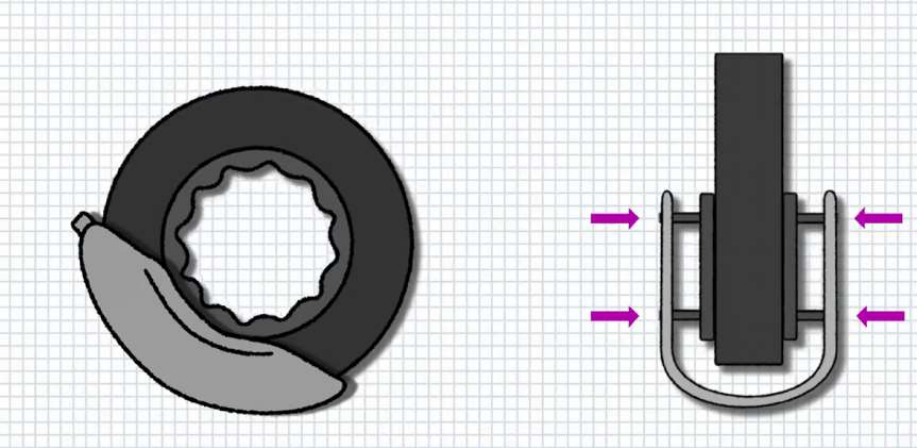
BME
DEPARTMENT OF AUTOMOTIVE TECHNOLOGIES

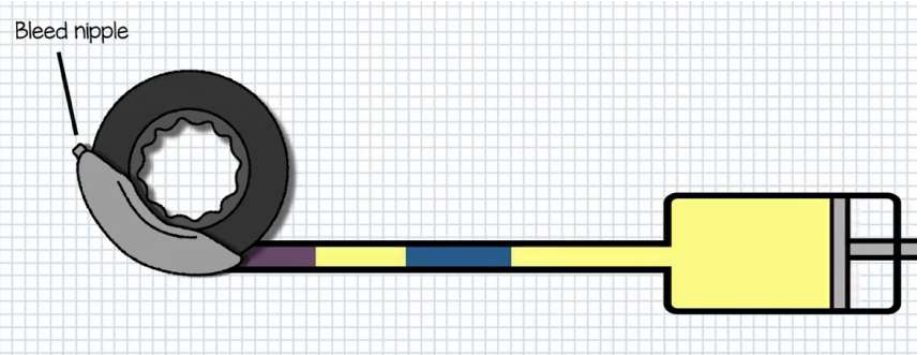
Comments

Braking video

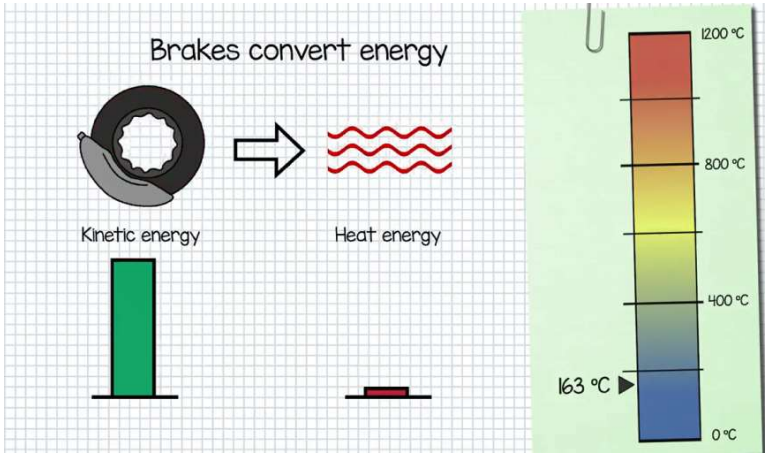


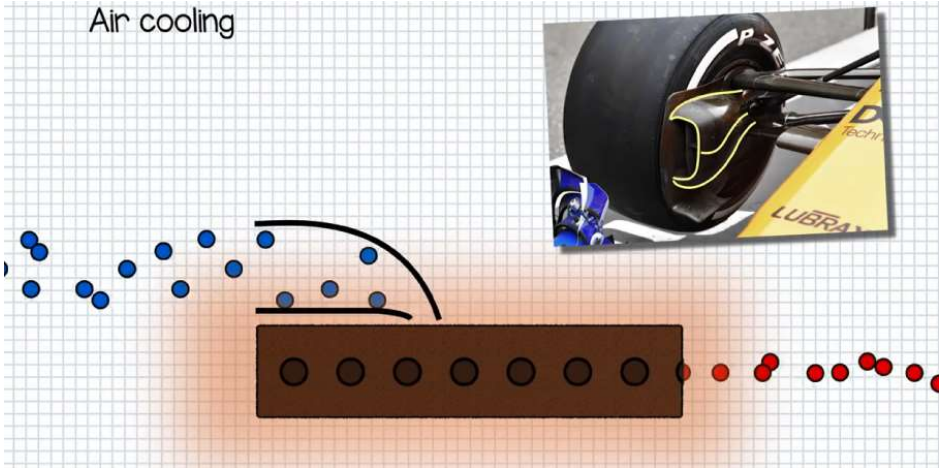




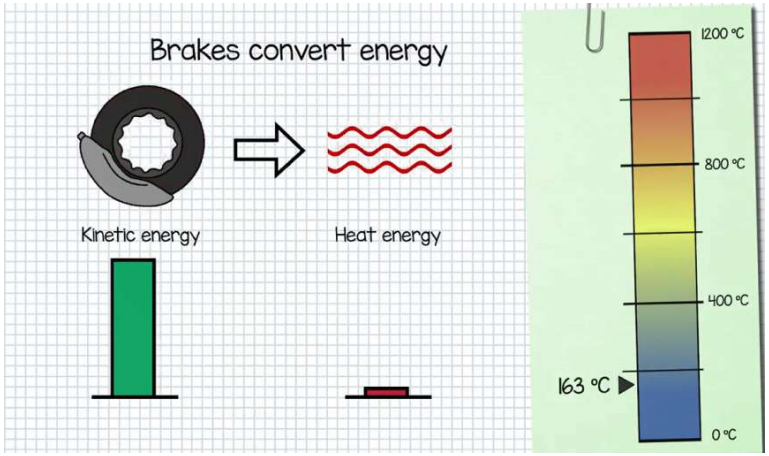


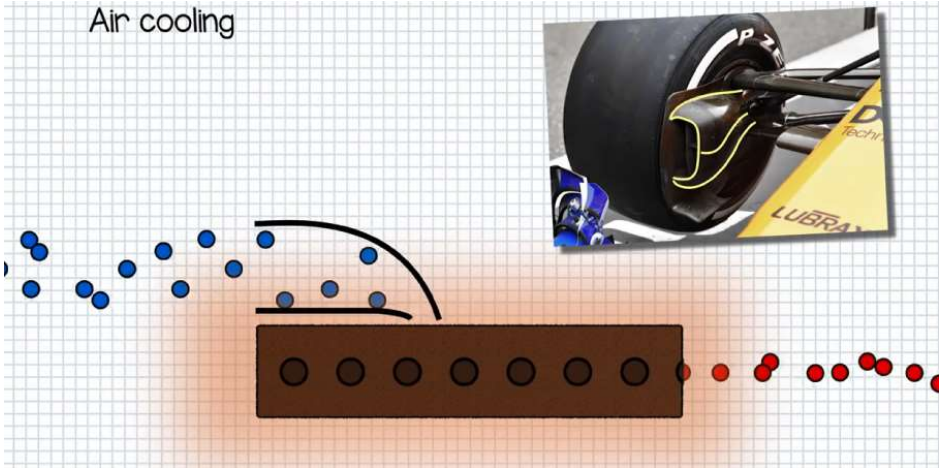
Braking video

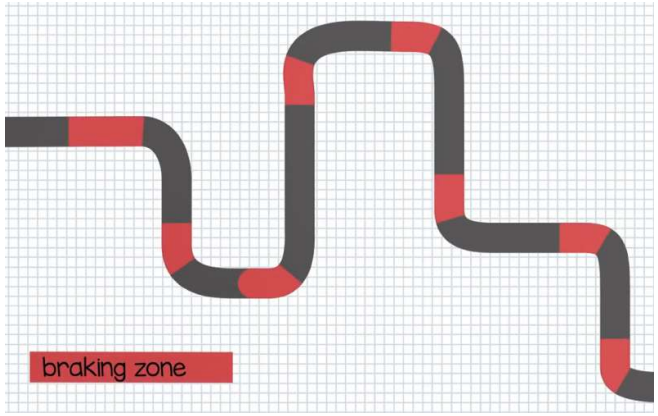


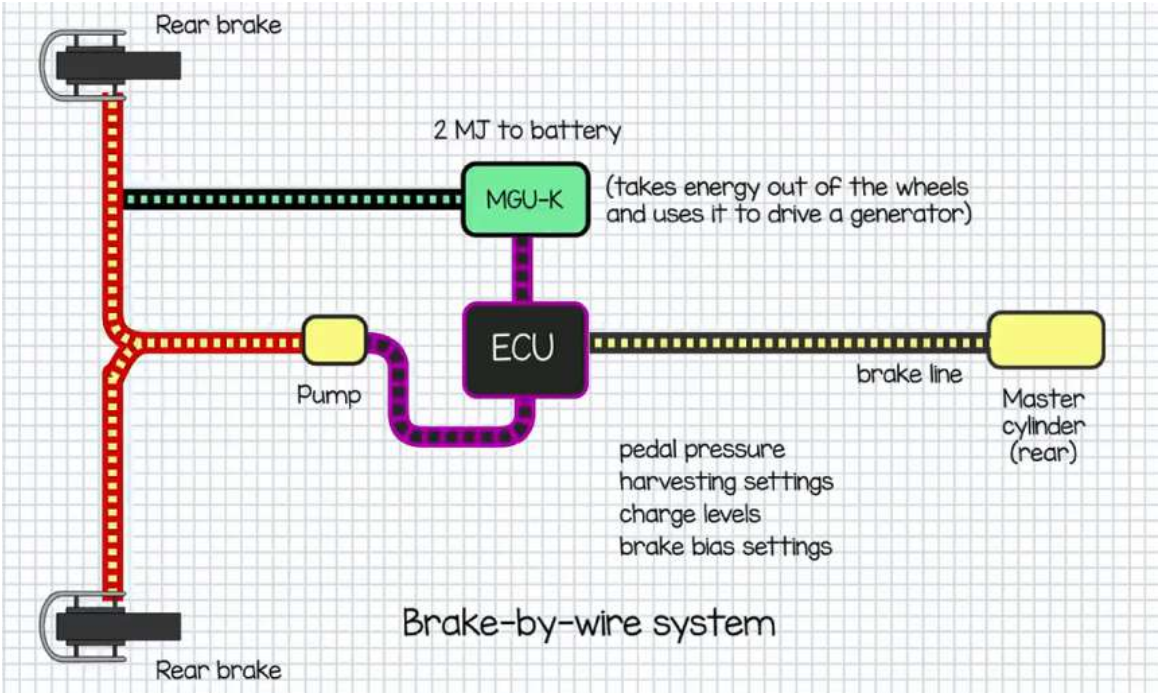


Braking video

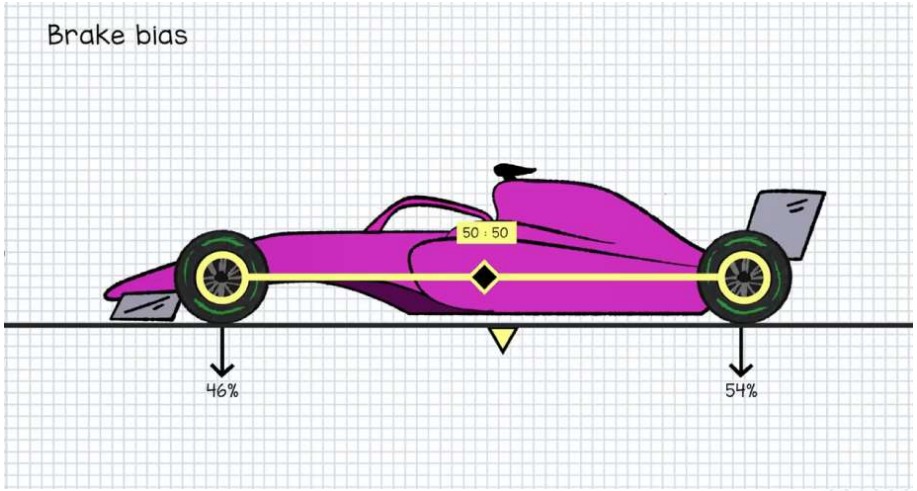


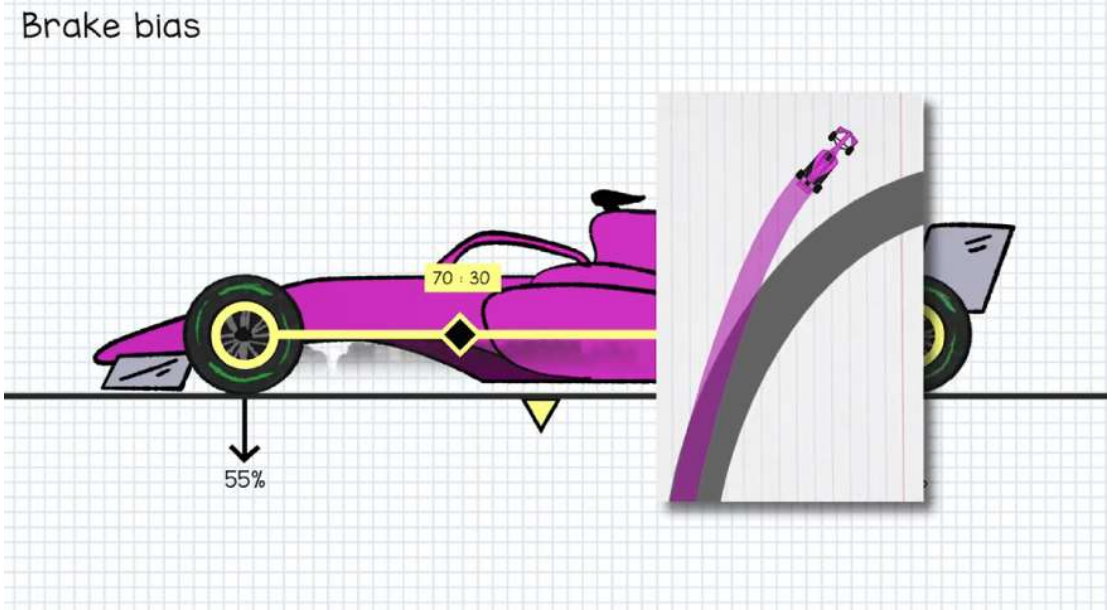






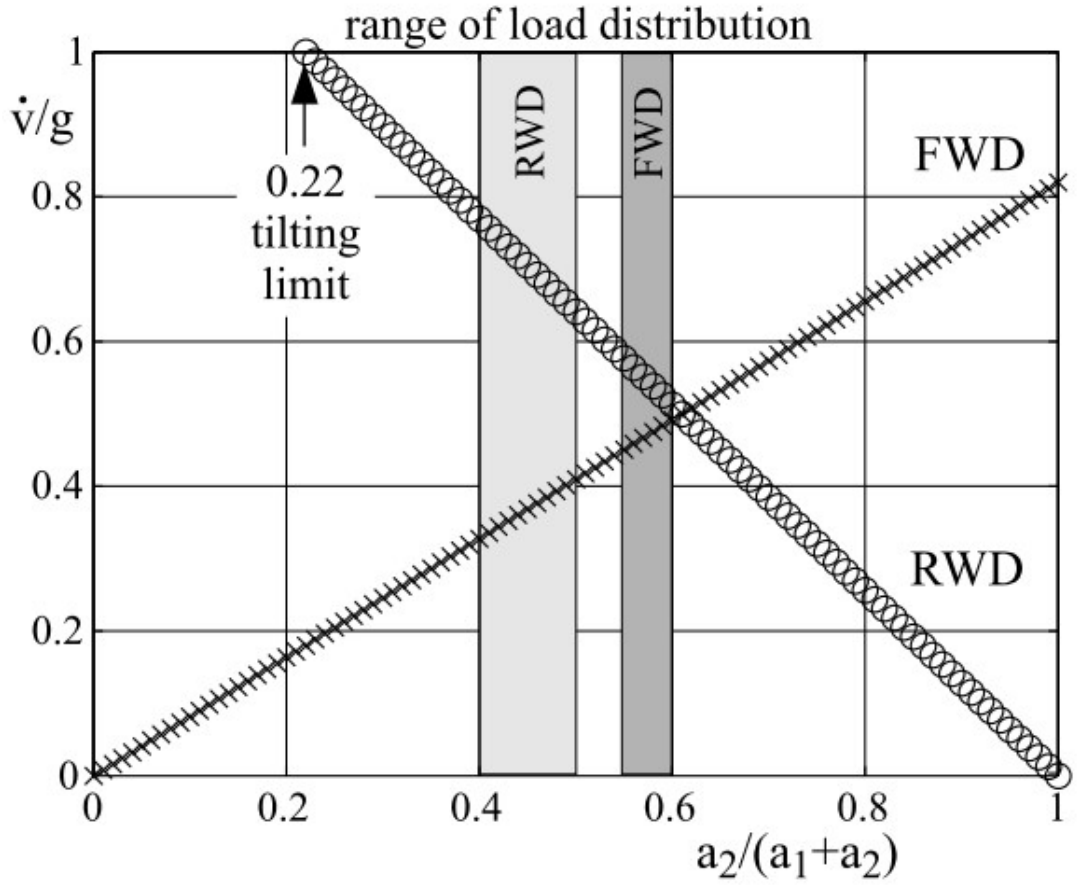
Braking video





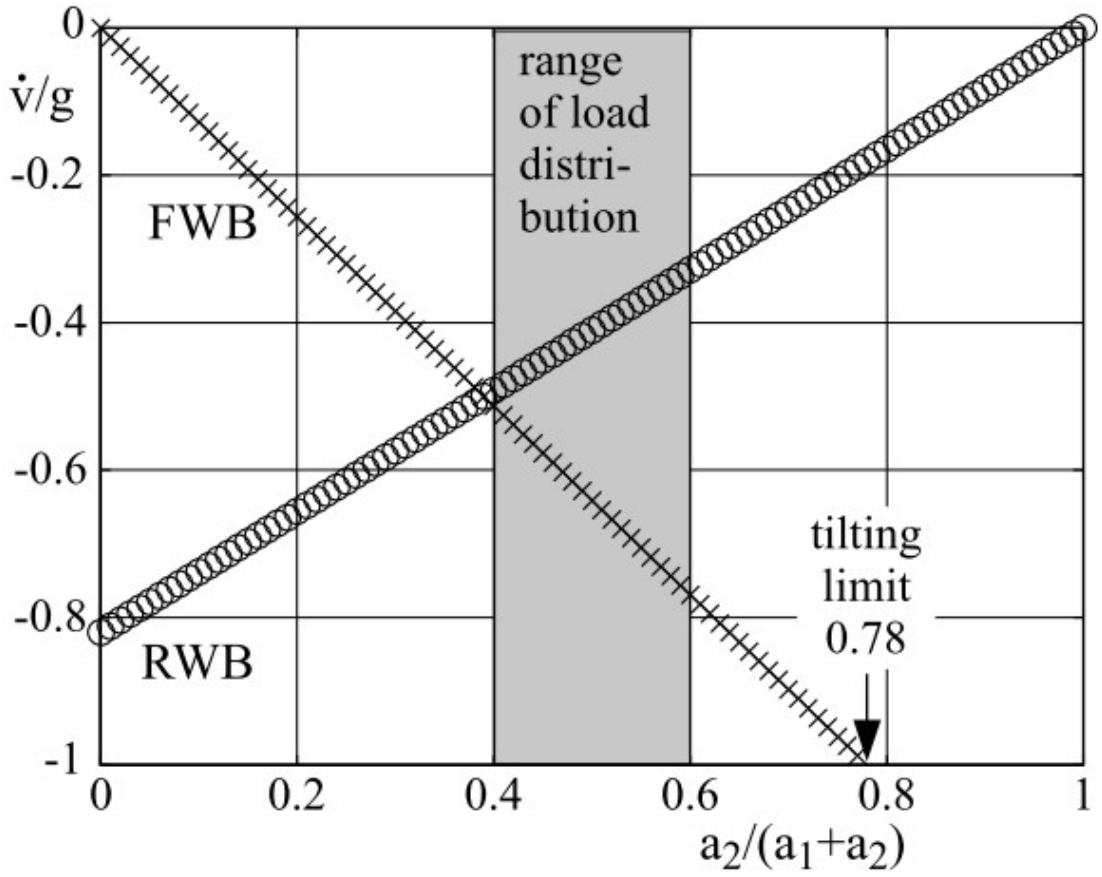
Drive one axle / Brake one axle

Drive case



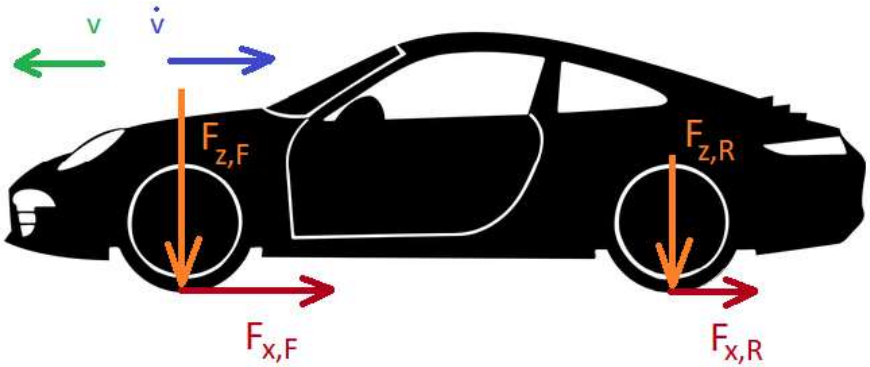
Drive one axle / Brake one axle

Brake case

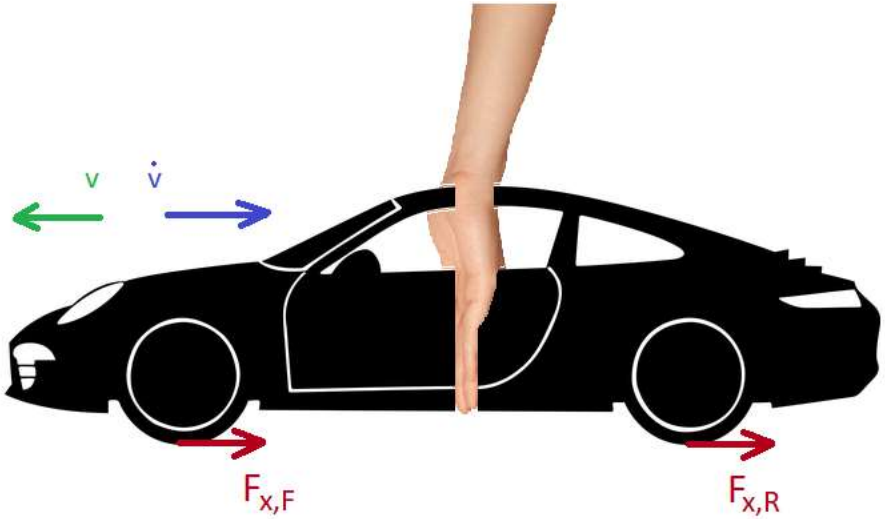


Optimal braking force distribution

Two different approach:



We have to brake ‚more load' in fornt, therefore we need more braking force.



Cut in two -> do not squeeze or tear apart during braking

Optimal braking force distribution

- Most of the rainy F1 races we hear radio messages: ‚Driver name', please go **** with the braking force!

Optimal braking force distribution

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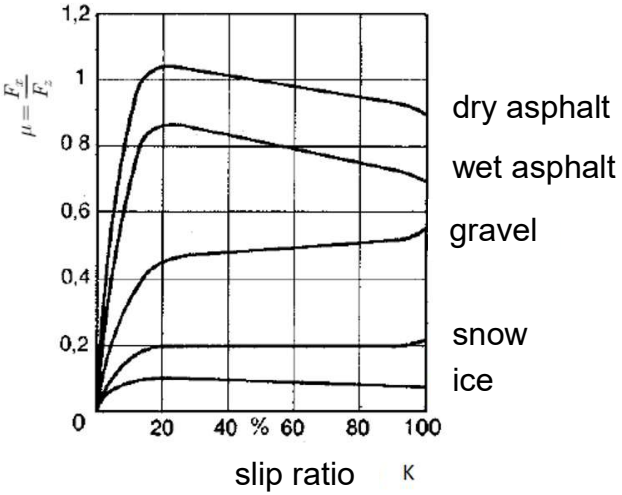
It rains, value of μ is decrasing → the available deceleration is less → longitudinal weight transfer is less → less front axle load → less available Fx

Optimal braking force distribution

It rains, value of μ is decrasing → the available deceleration is less → longitudinal weight transfer is less → less front axle load → less available Fx

$$\dot{v}_{max} = \mu \cdot g$$

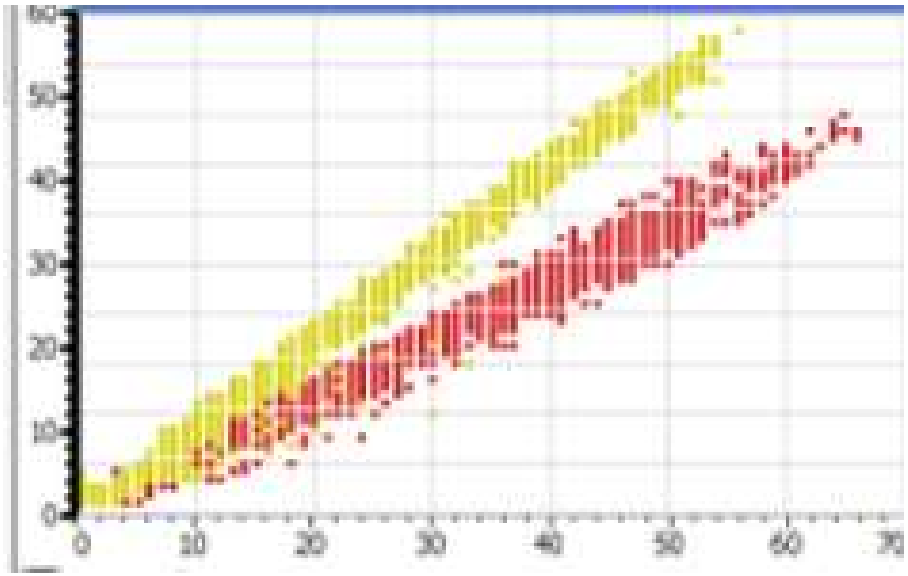
$$\mu_x \cdot F_z = F_x$$



$$F_{z,F} = m \cdot g \cdot \frac{a_2}{w} + \frac{h}{w} \cdot m \cdot \dot{v}_{max}$$

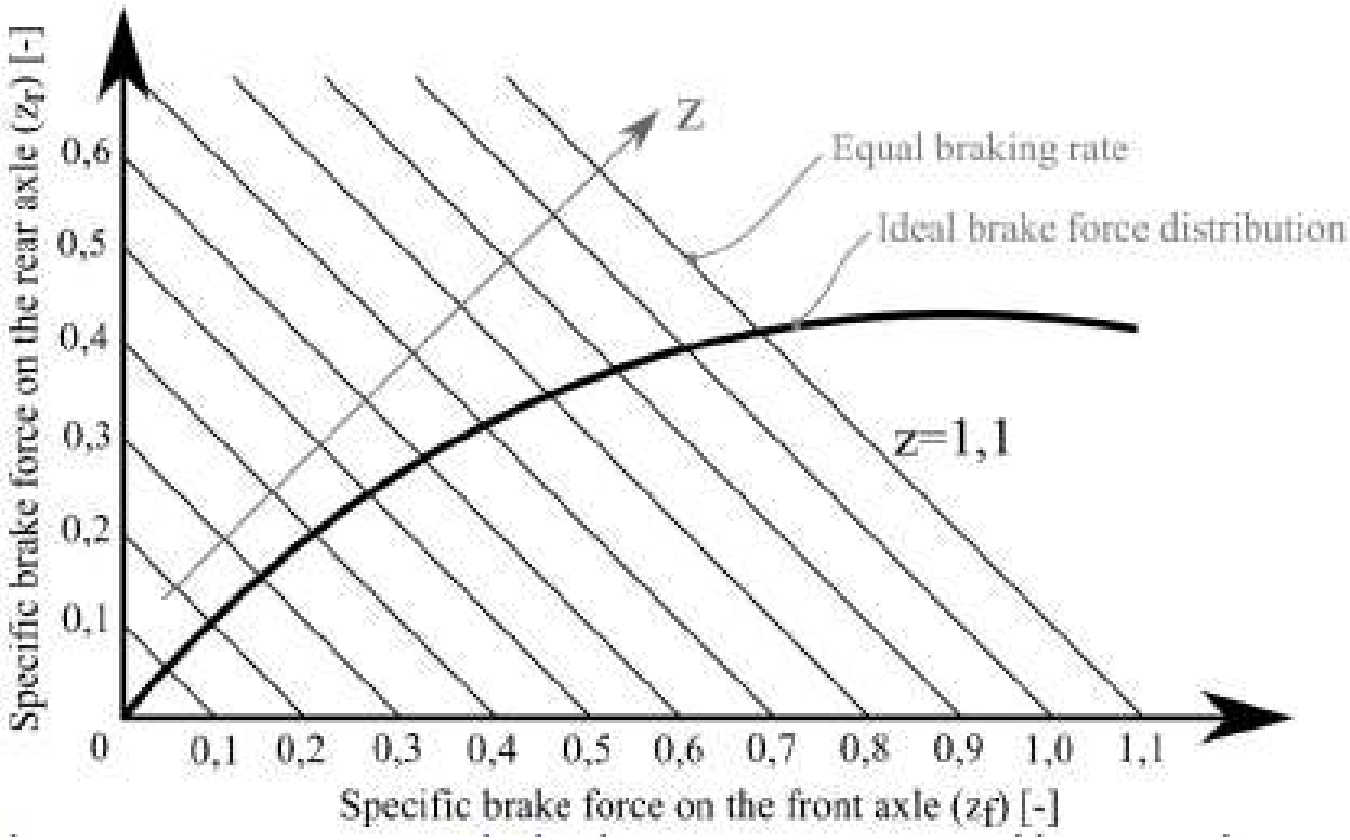
$$F_{z,R} = m \cdot g \cdot \frac{a_1}{w} - \frac{h}{w} \cdot m \cdot \dot{v}_{max}$$

Optimal braking force distribution



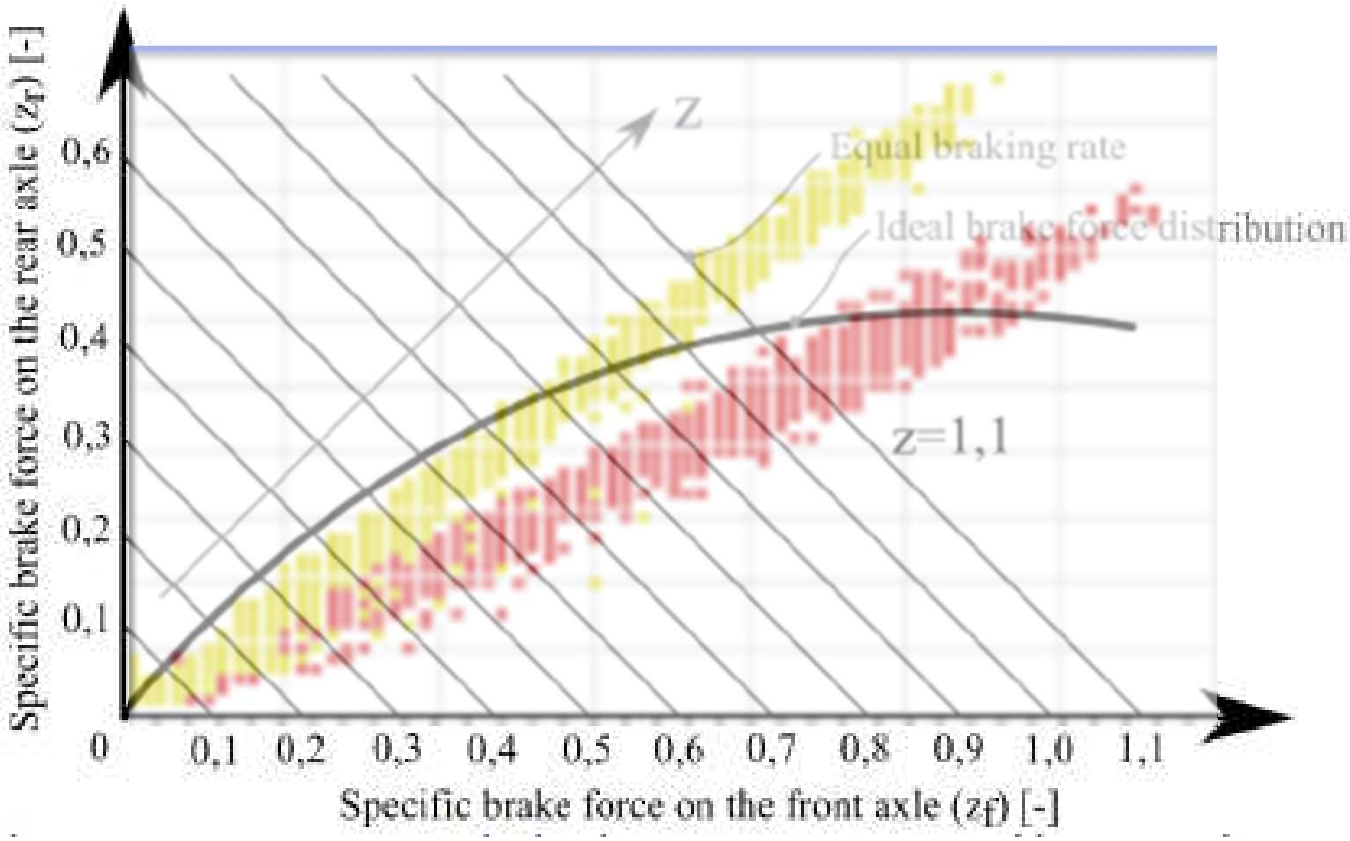
Optimal braking force distribution

Balance bar and proportional valve



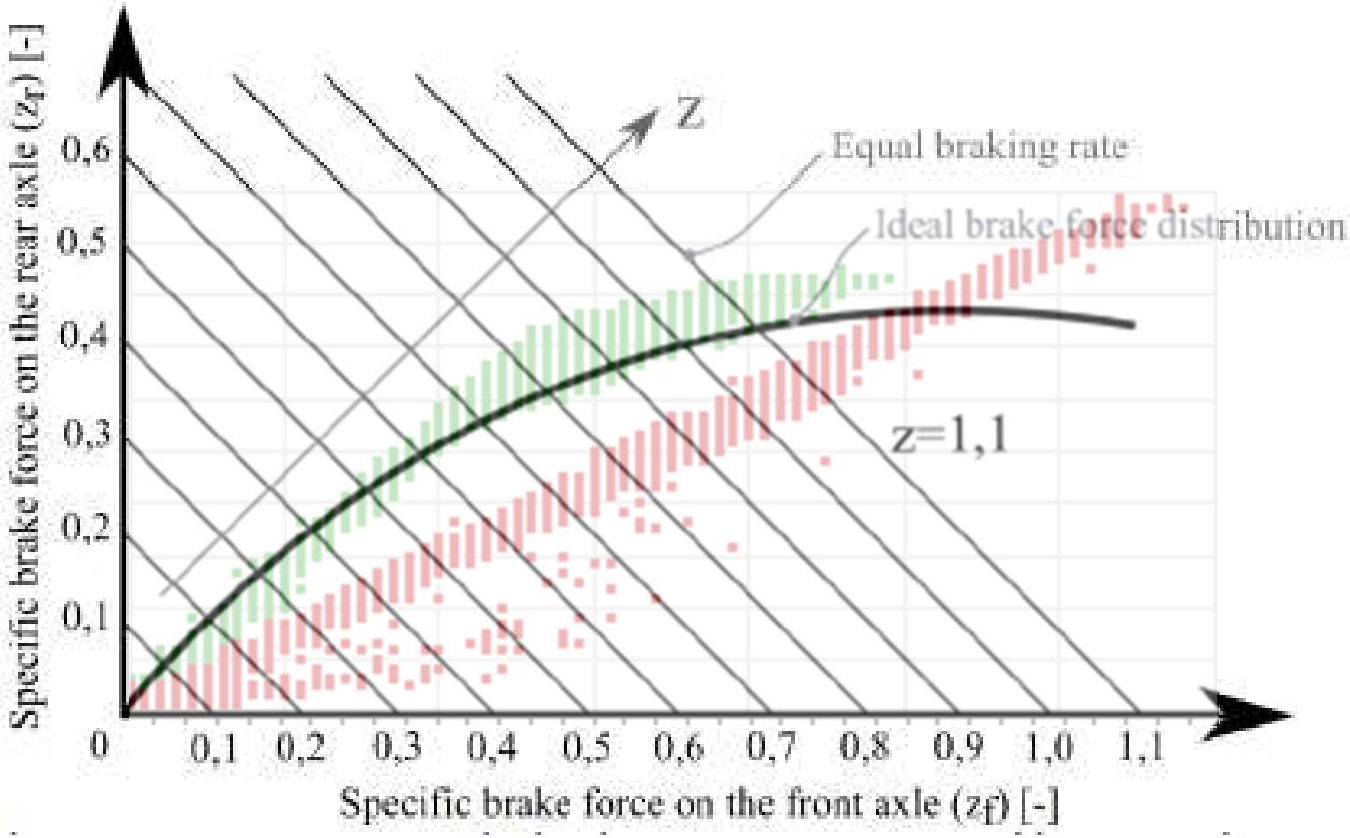
Optimal braking force distribution

Balance bar and proportional valve



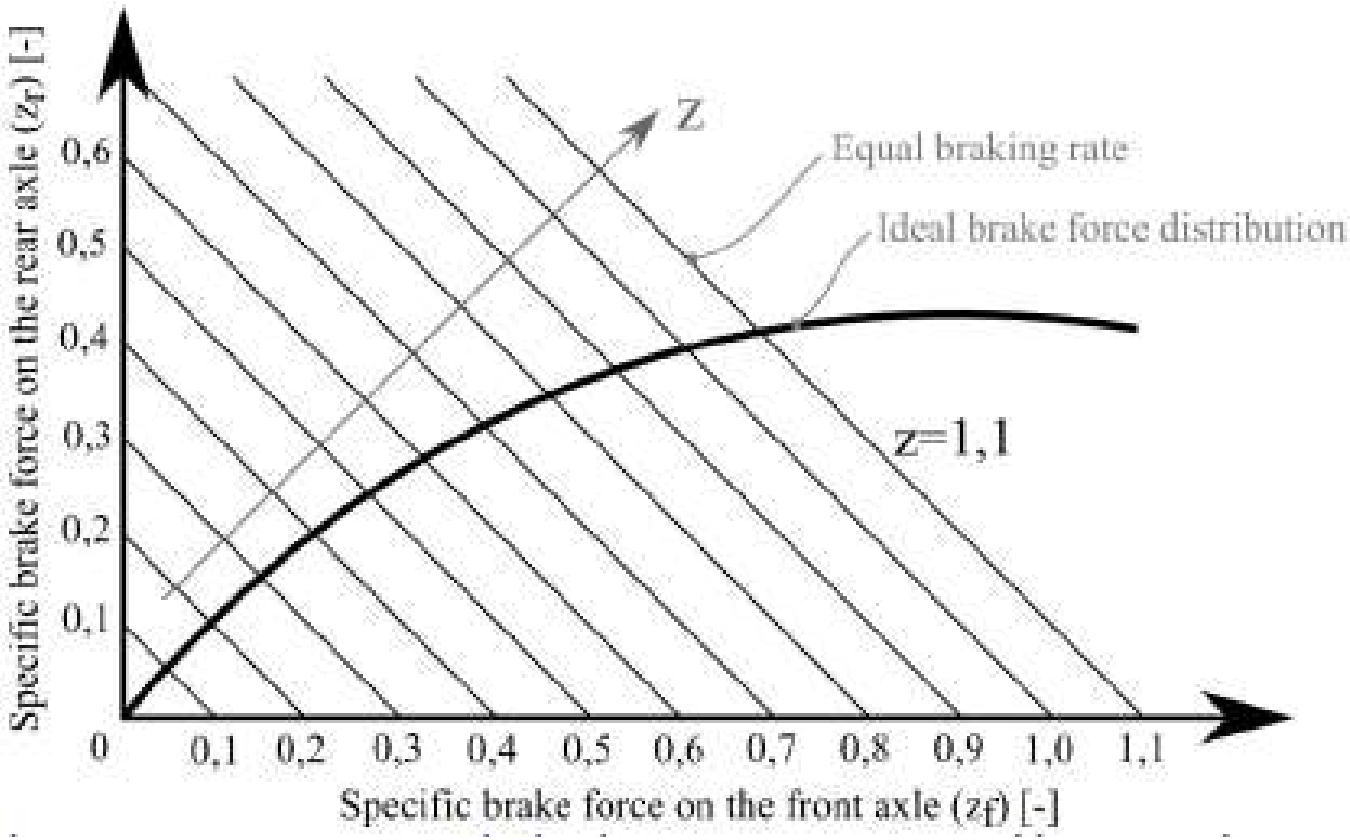
Optimal braking force distribution

Balance bar and proportional valve



Optimal braking force distribution

Balance bar and proportional valve



$$\frac{F_{B,f}}{G_g} + \frac{F_{B,r}}{G_g} = z_f + z_r = z \qquad z = \frac{a}{g} = \mu$$

Optimal braking force distribution

Balance bar and proportional valve

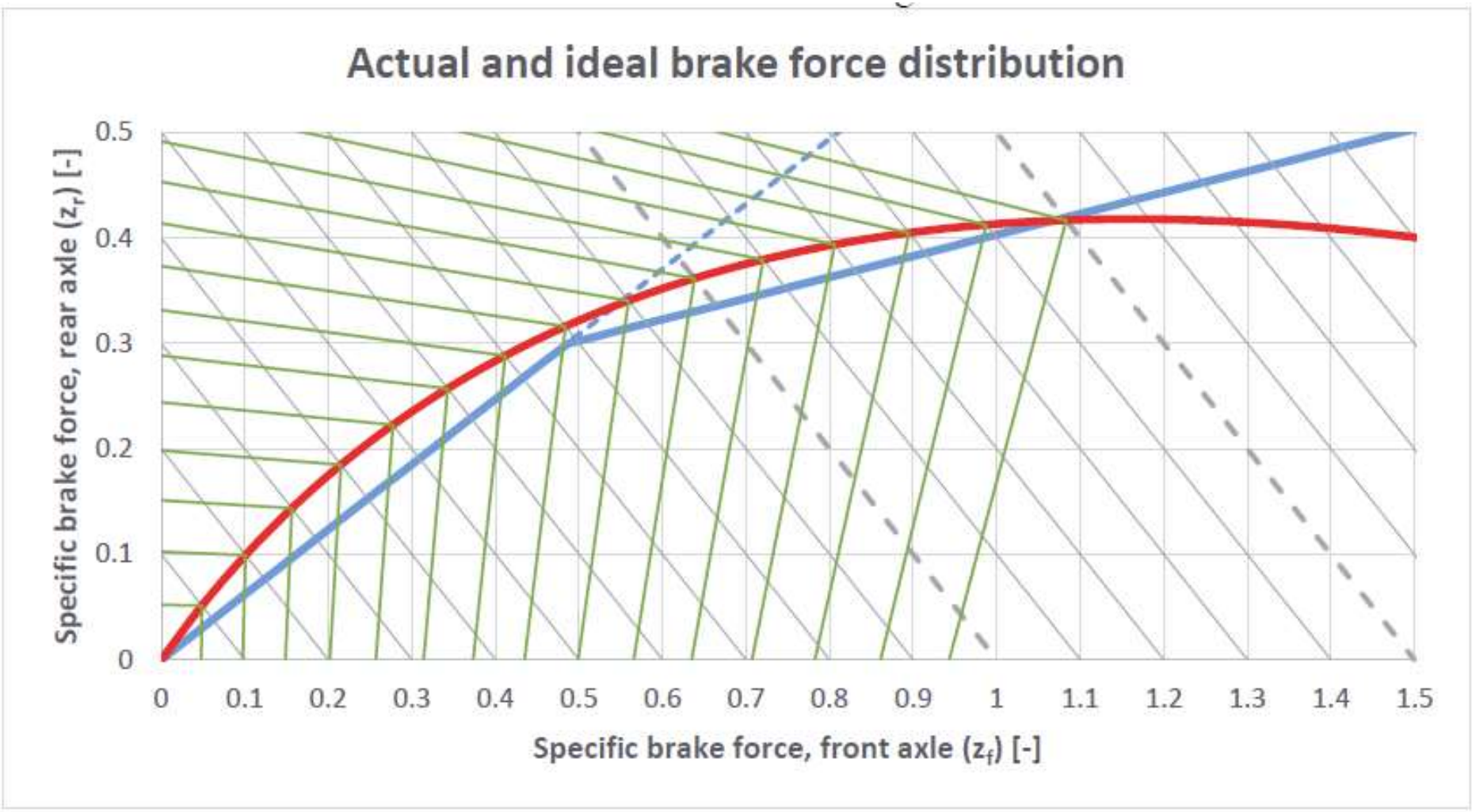
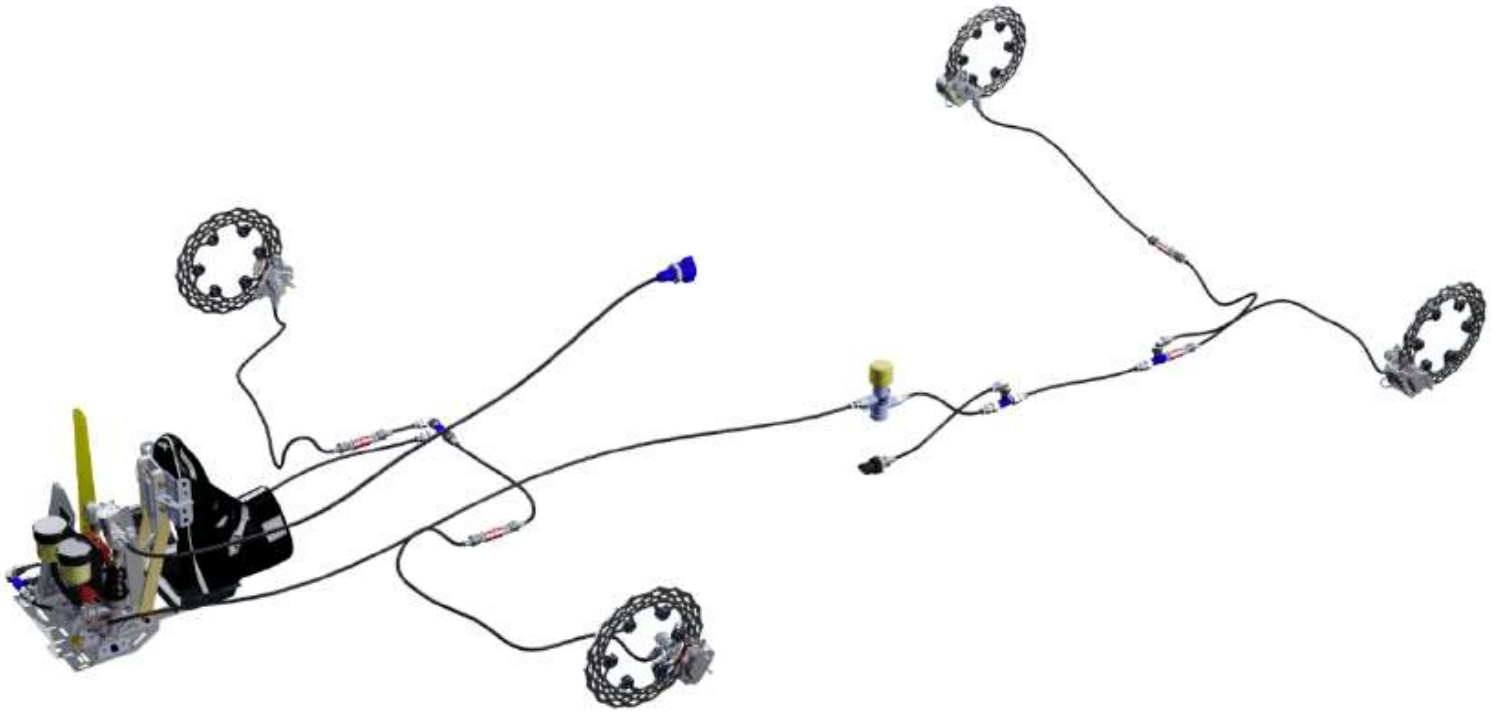


Figure 69 – Actual and ideal brake force distribution of FREC-005

Optimal braking force distribution

Balance bar and proportional valve



Power flow:

Brake pedal

↓

Balance bar

↓

Master cylinders

↓

Proportioning valve

↓

Brake calipers

↓

Brake pads

↓

Brake discs

↓

Tires

Optimal braking force distribution

Balance bar and proportional valve

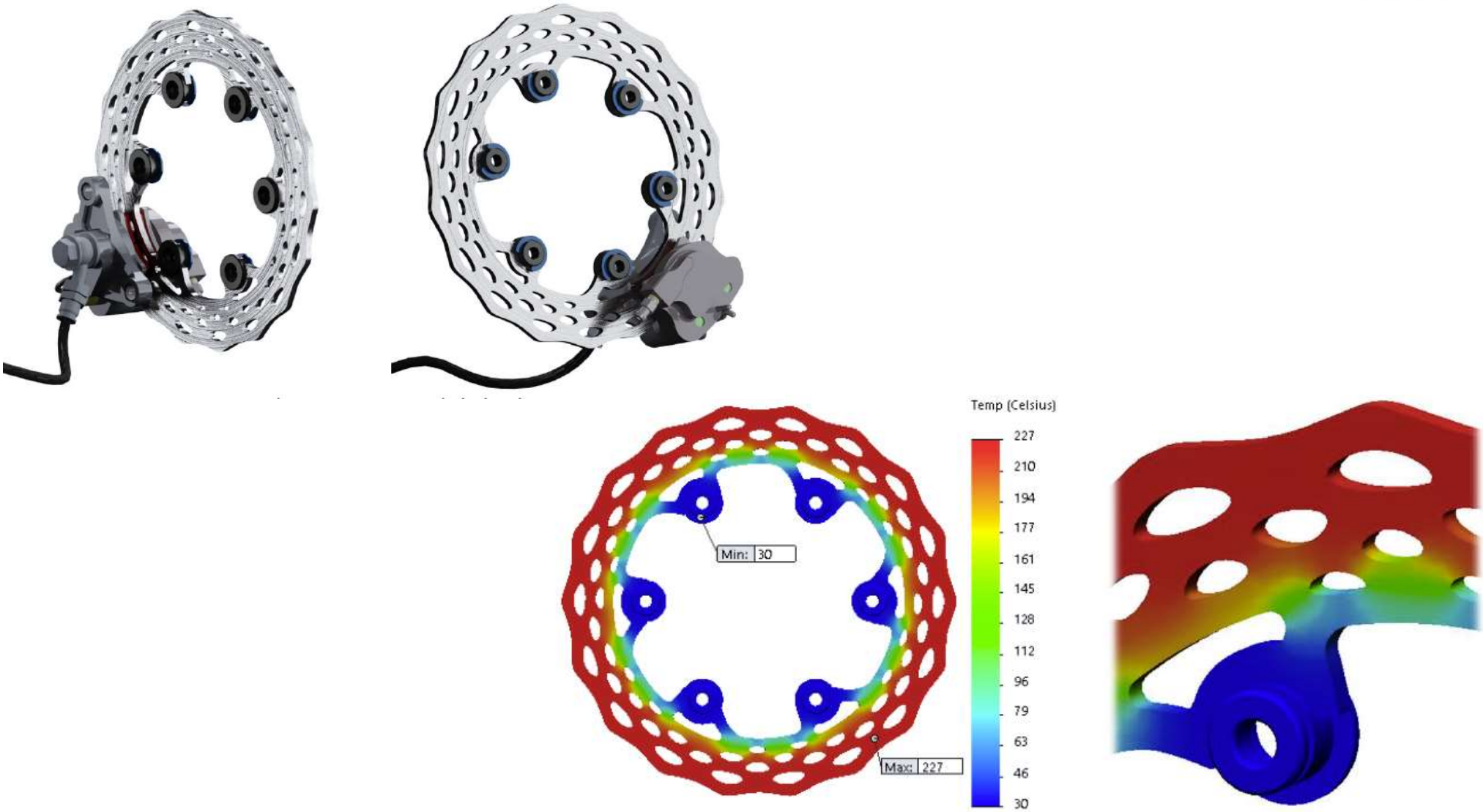
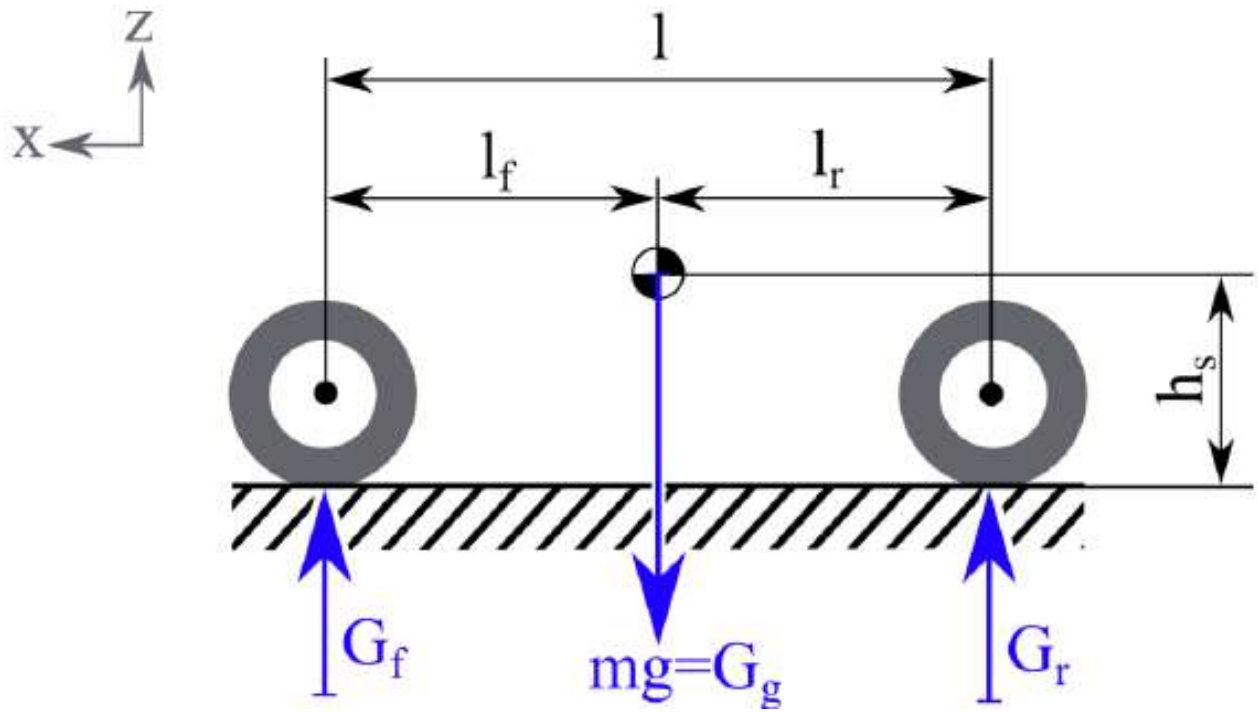


Figure 100 – Temperature distribution in the front brake discs after a single braking from cold brakes (FEA)

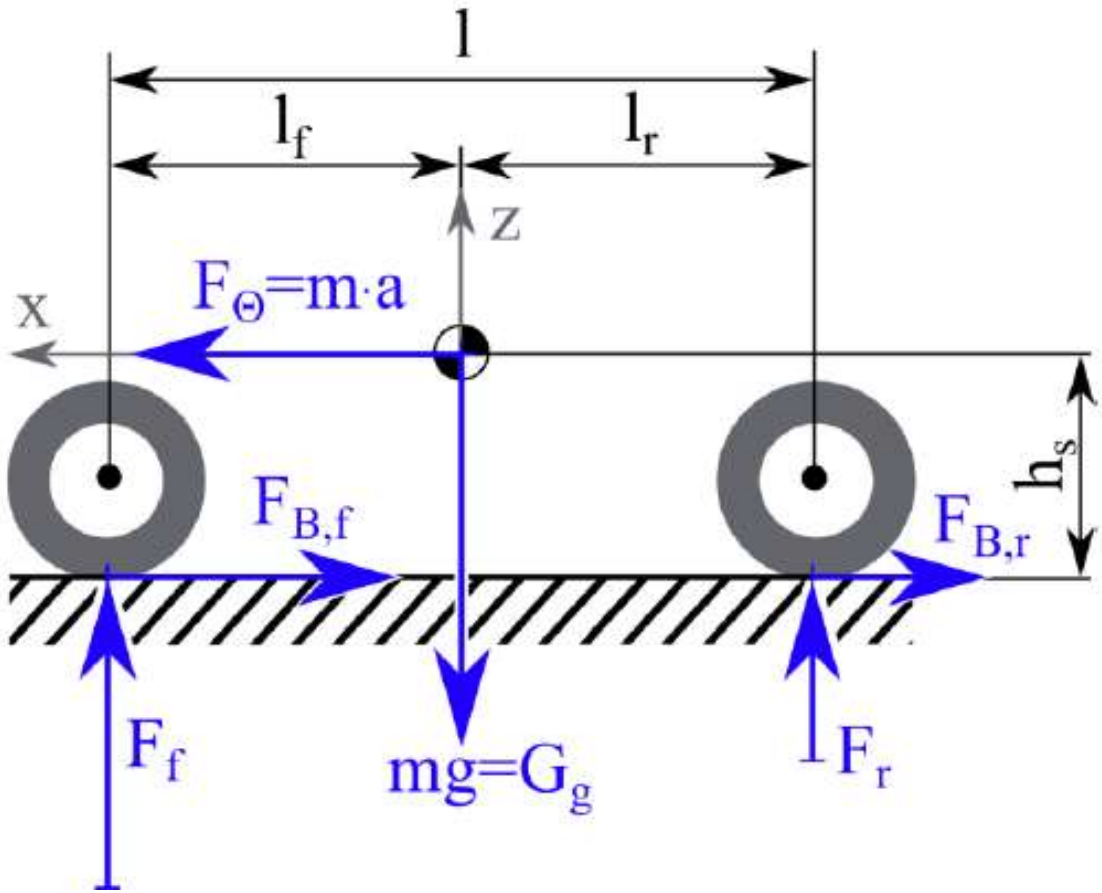
Optimal braking force distribution

Balance bar and proportional valve



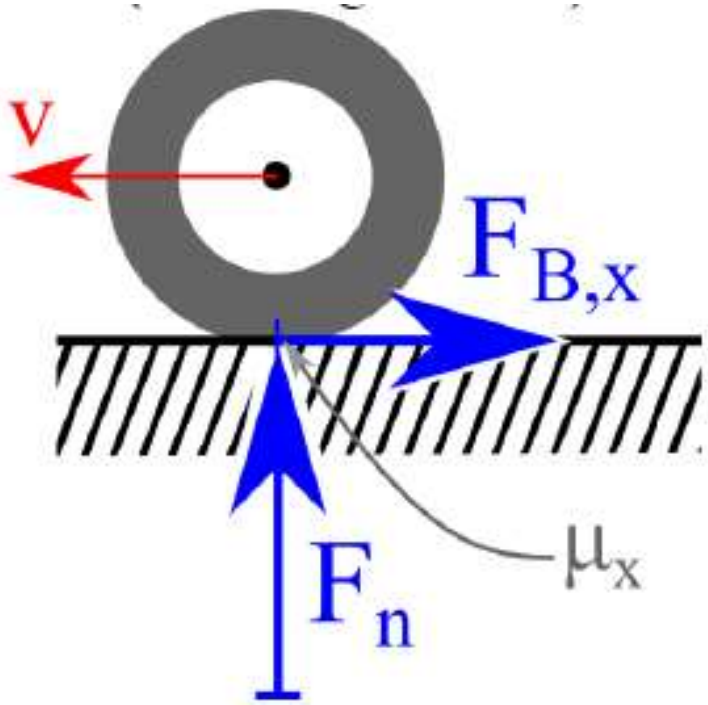
Optimal braking force distribution

Balance bar and proportional valve



Optimal braking force distribution

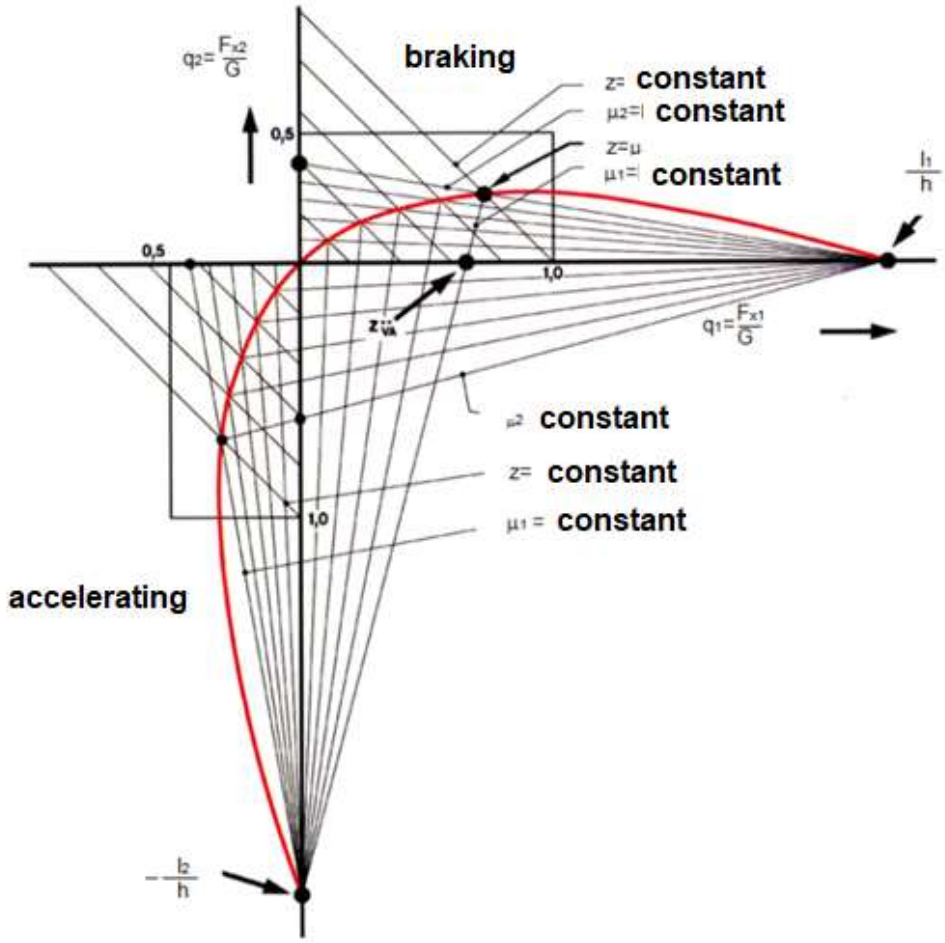
Balance bar and proportional valve



$$\mu_x = \frac{F_{B,x}}{F_n}$$

Optimal braking force distribution

Balance bar and proportional valve



Ideal specific drive and brake force

Optimal braking force distribution

Balance bar and proportional valve

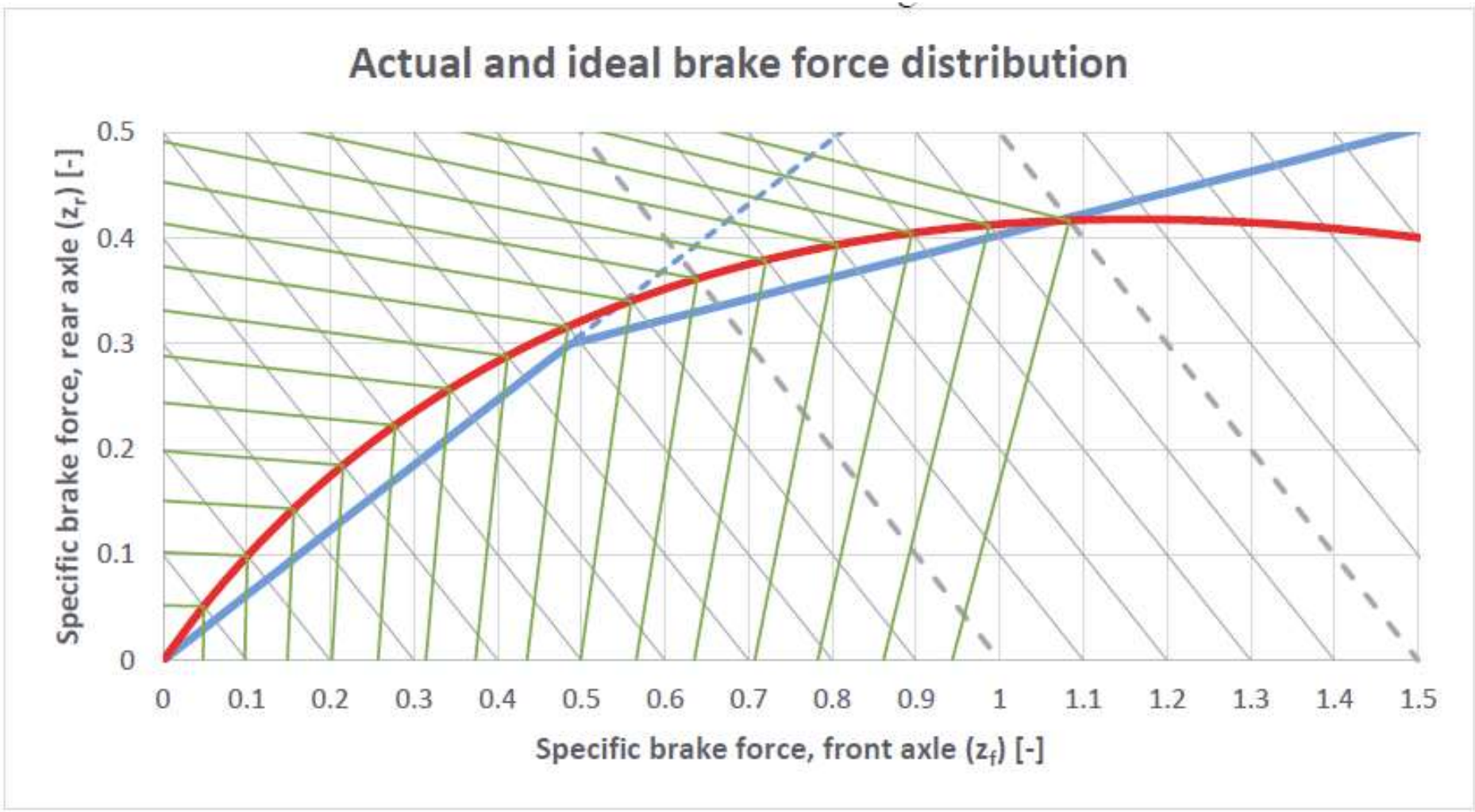


Figure 69 – Actual and ideal brake force distribution of FREC-005

Optimal braking force distribution

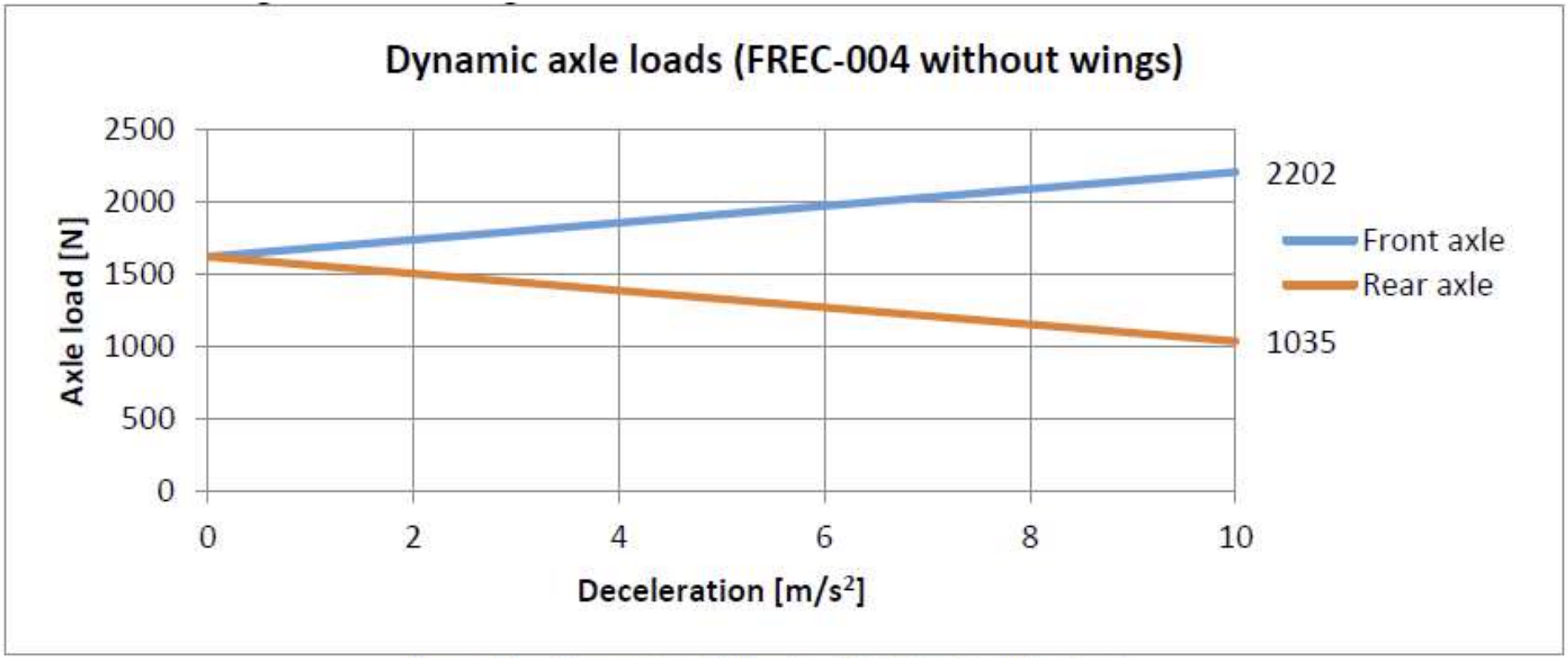


Figure 41 – Dynamic axle loads of FREC-004 without wings

Optimal braking force distribution

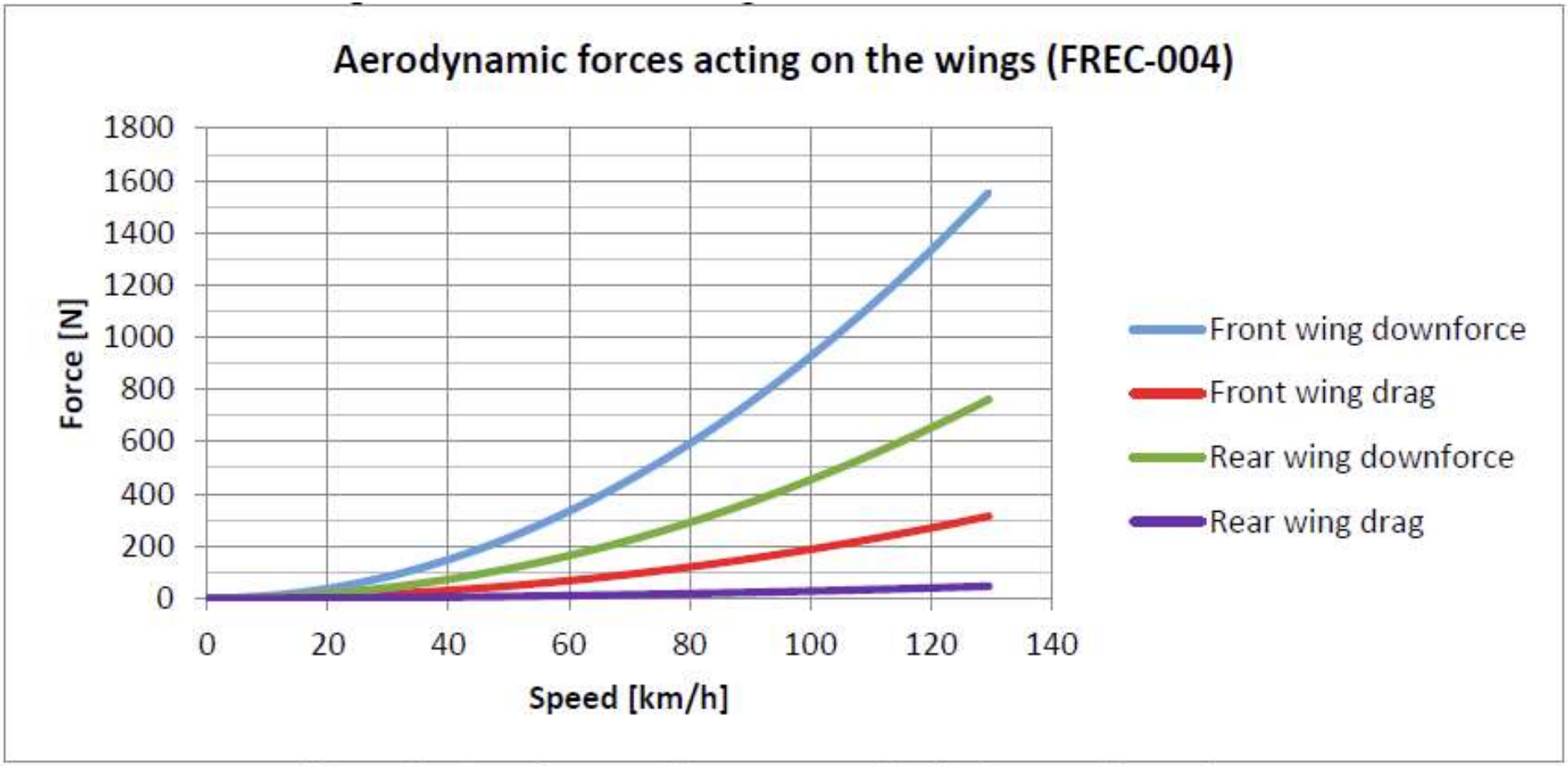


Figure 44 – Downforces and drag generated by the front- and rear wings

Optimal braking force distribution

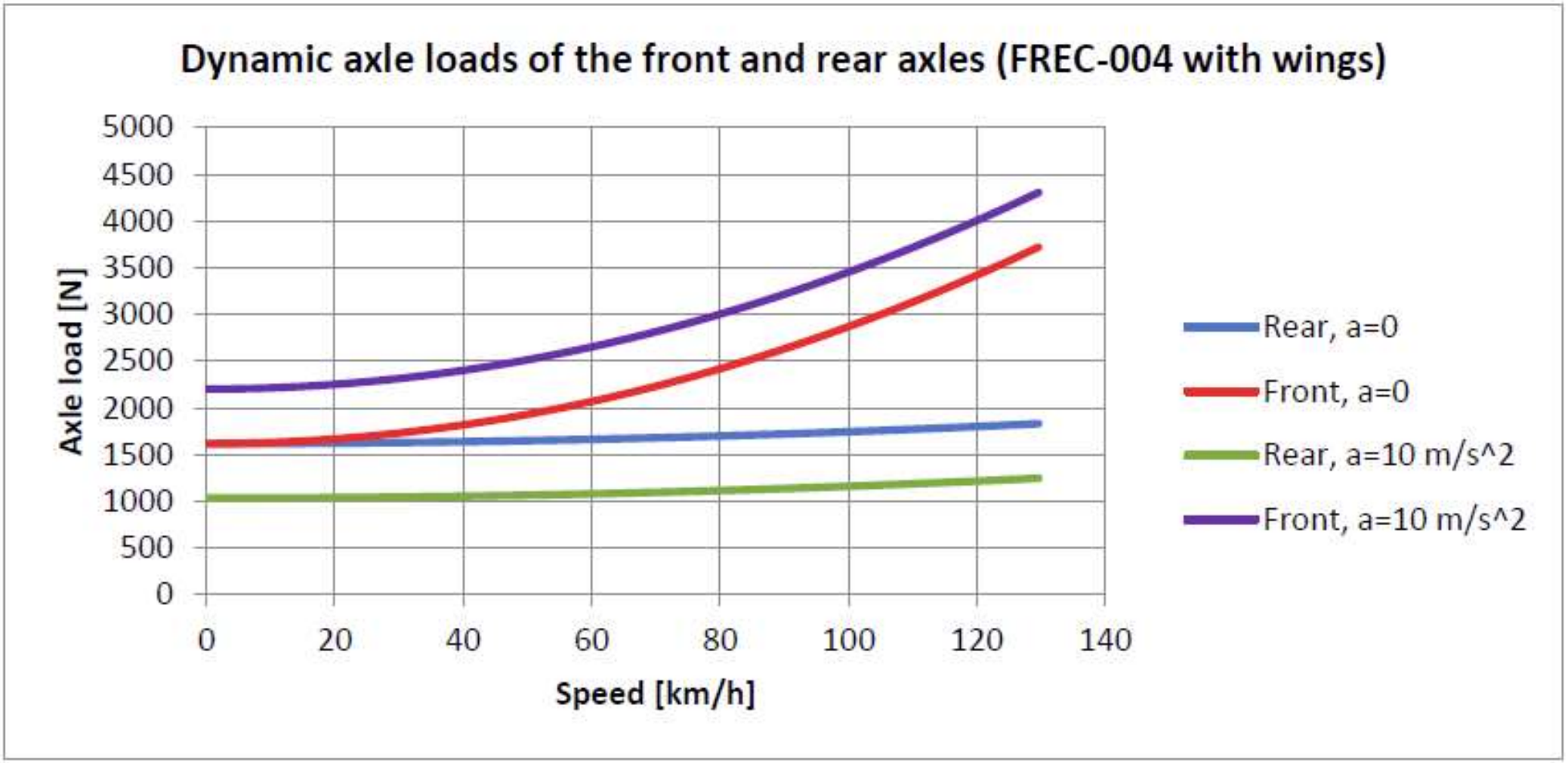


Figure 45 – Dynamic axle loads of the front and rear axles of FREC-004 with wings

Optimal braking force distribution

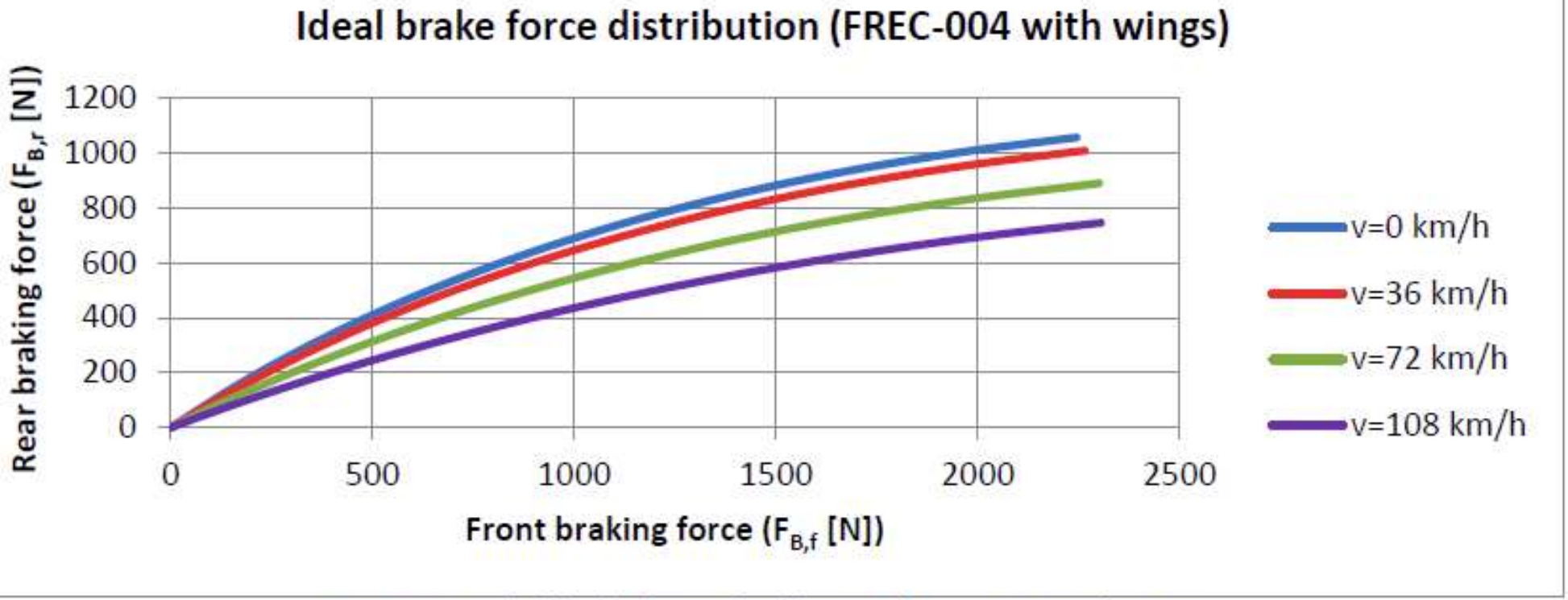


Figure 46 – Ideal brake force distribution of FREC-004 with wings

Optimal braking force distribution

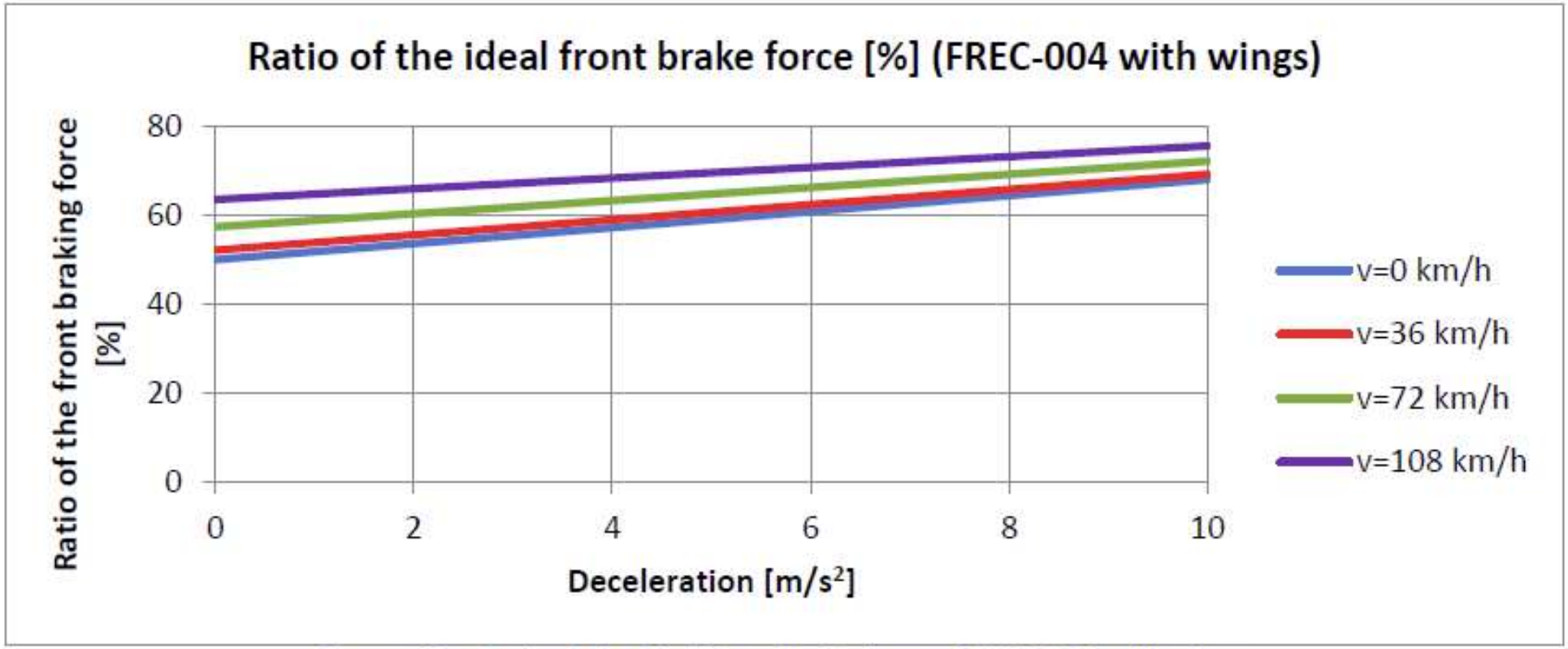


Figure 47 – Ratio of the ideal front brake force of FREC-004 with wings

Optimal braking force distribution

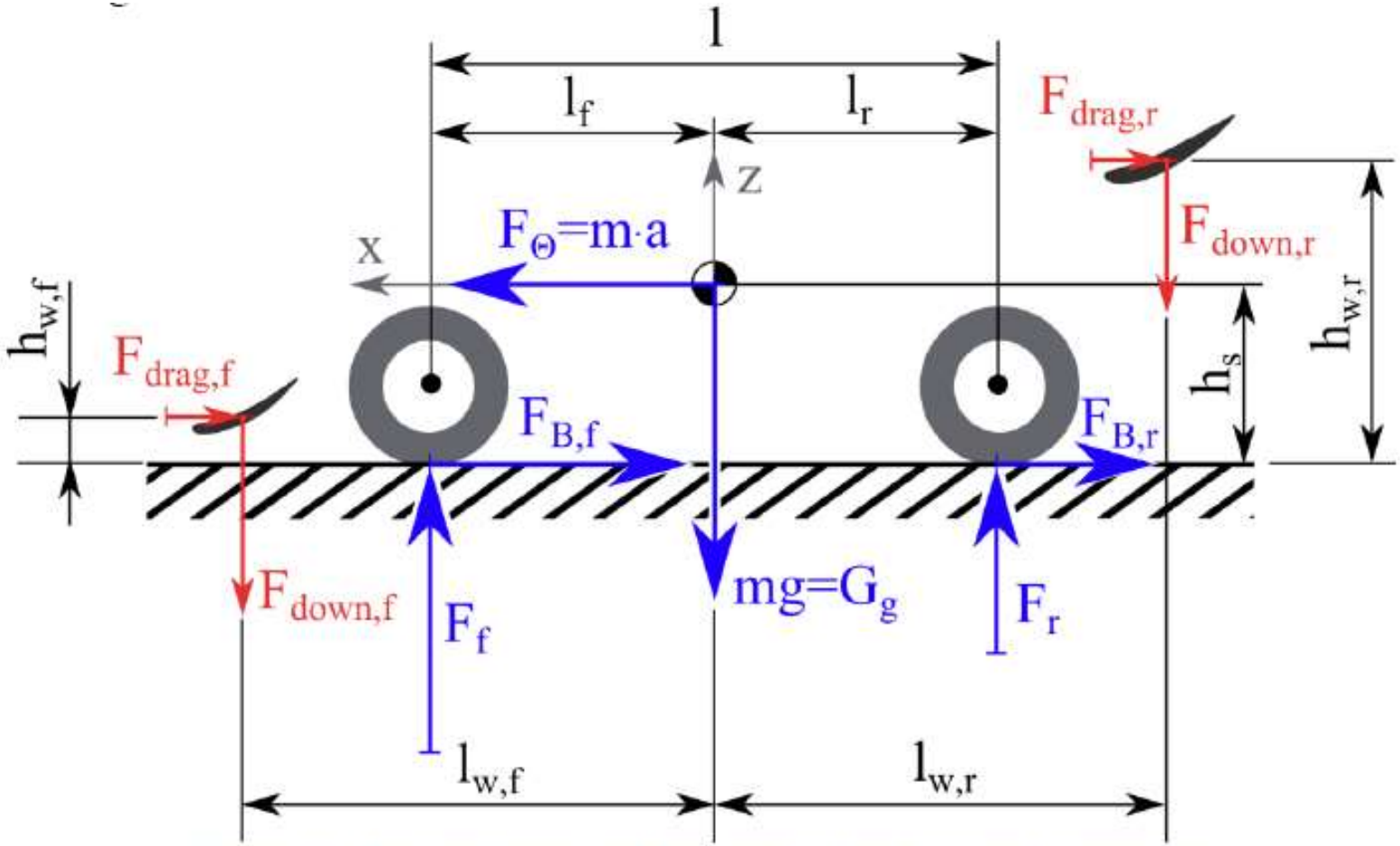


Figure 40 – Dynamic forces with the use of a front wing and a rear wing

$$F_{drag} = c_D \cdot A_D \cdot \frac{\rho}{2} \cdot v^2$$

$$F_{down} = c_L \cdot A_L \cdot \frac{\rho}{2} \cdot v^2$$

Aero efficiecy

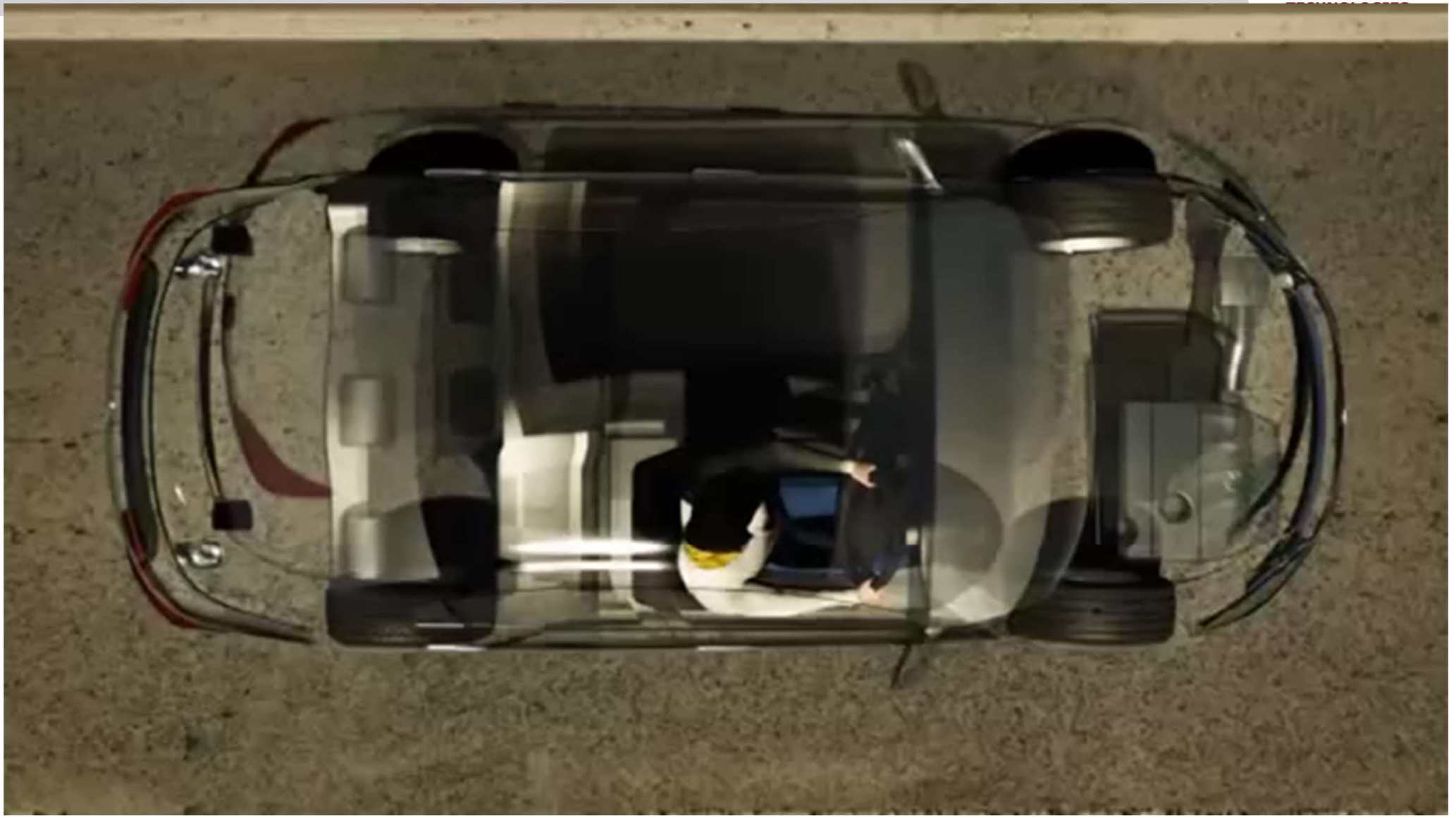
$$\left|\frac{c_l}{c_d}\right| = Aero\ efficiency$$

- 0 would mean cd is zero.
- You can develop this value cd will change.

$$F_{drag} = c_D \cdot A_D \cdot \frac{\rho}{2} \cdot v^2$$

$$F_{down} = c_L \cdot A_L \cdot \frac{\rho}{2} \cdot v^2$$

EBD



Midterm tests and exams

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1

- know concepts and definitions – you are able to give definitions of :
  - different type of tyre radius
  - contact patch
  - tyre structures
  - slip ratio
  - slip angle
  - aware of the different characteristics of tyre behaviour and able to distinguish one from other
  - friction coefficient
  - brush tyre model and explanation of tyre force
  - able to orientate in the coordinate system of a vehicle
  - cornering stiffnes of a tyre
  - self aligning torque
  - pneumatic trail
  - friction ‚cirle'
  - steady state basics equations
  - transient basics equation
  - characteristics of transient basics diagrams

Midterm tests and exams

2

- assymetric tyre behaviour to acceleration and braking
- static vertical tyre loads
- longitudinal weight transfer with the help of longitudinal model
- lateral weight transfer in steady state cornering
- understanding the effect of tyre degressivity and weight transfer
- Bicycle model usage
- braking system components
- optimal brake force distribution
- specific braking force
- EBD basic working principle
- Motorsport relevant braking aspects

Q & A

- Main objective?
- Starting point - ending point?
- Complex parts?
- Less relevant part(s), could be omitted part(s)?
- Most useful part(s)?
- How could today’s material have contributed to your professional goals?

Bibliography

- https://www.youtube.com/watch?v=S0TlRkNWheQ
- https://www.youtube.com/watch?v=0ykCdaRzn5g
- http://moodle.autolab.uni-pannon.hu/Mecha_tananyag/kozuti_jarmurendszerek_szerkezettana/ch13.html

Thank you for your attention!