Department of Automotive Technologies –
Vehicle Mechanics Fundamentals
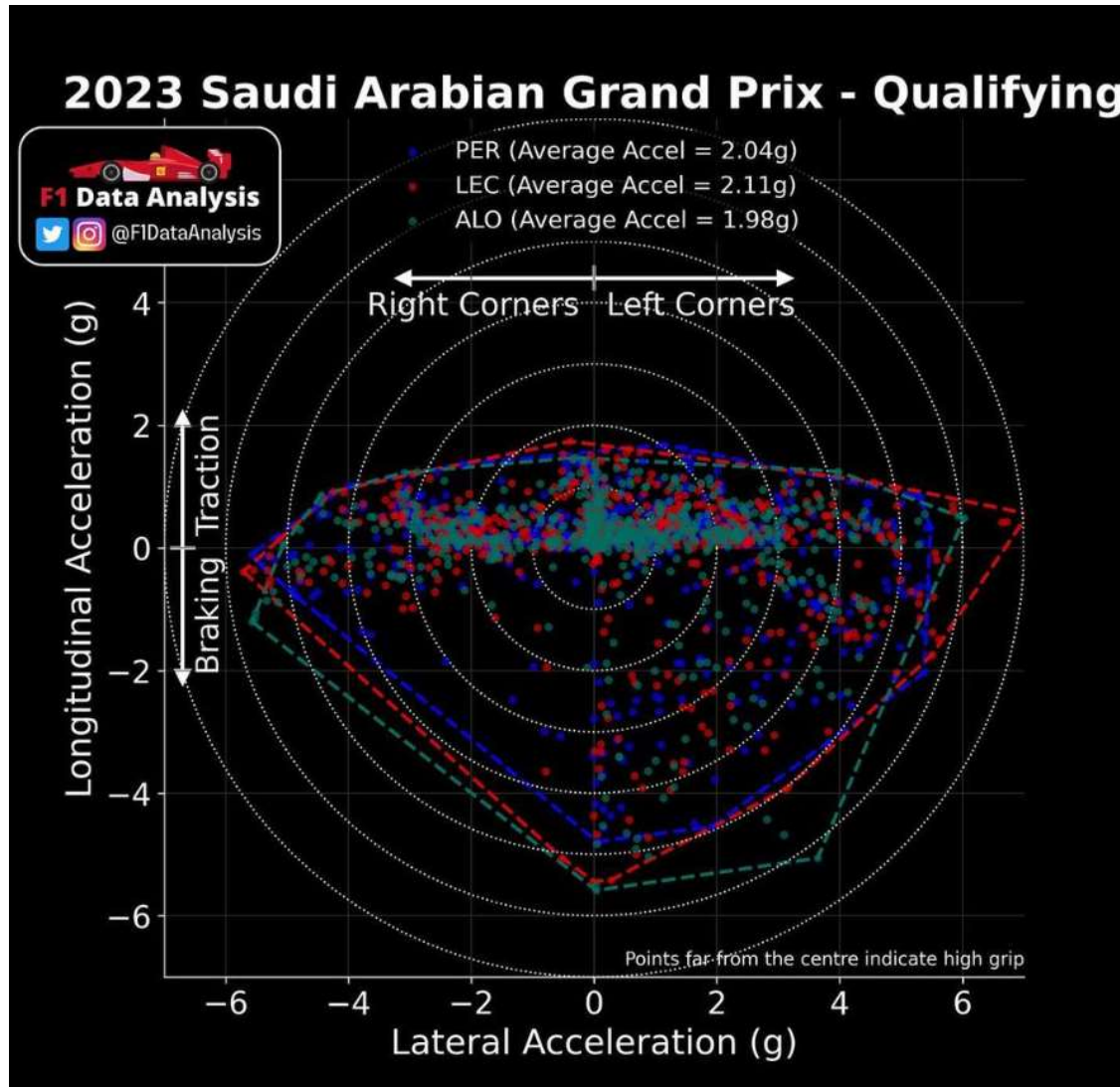
Gábor Sipos

Practical course 3
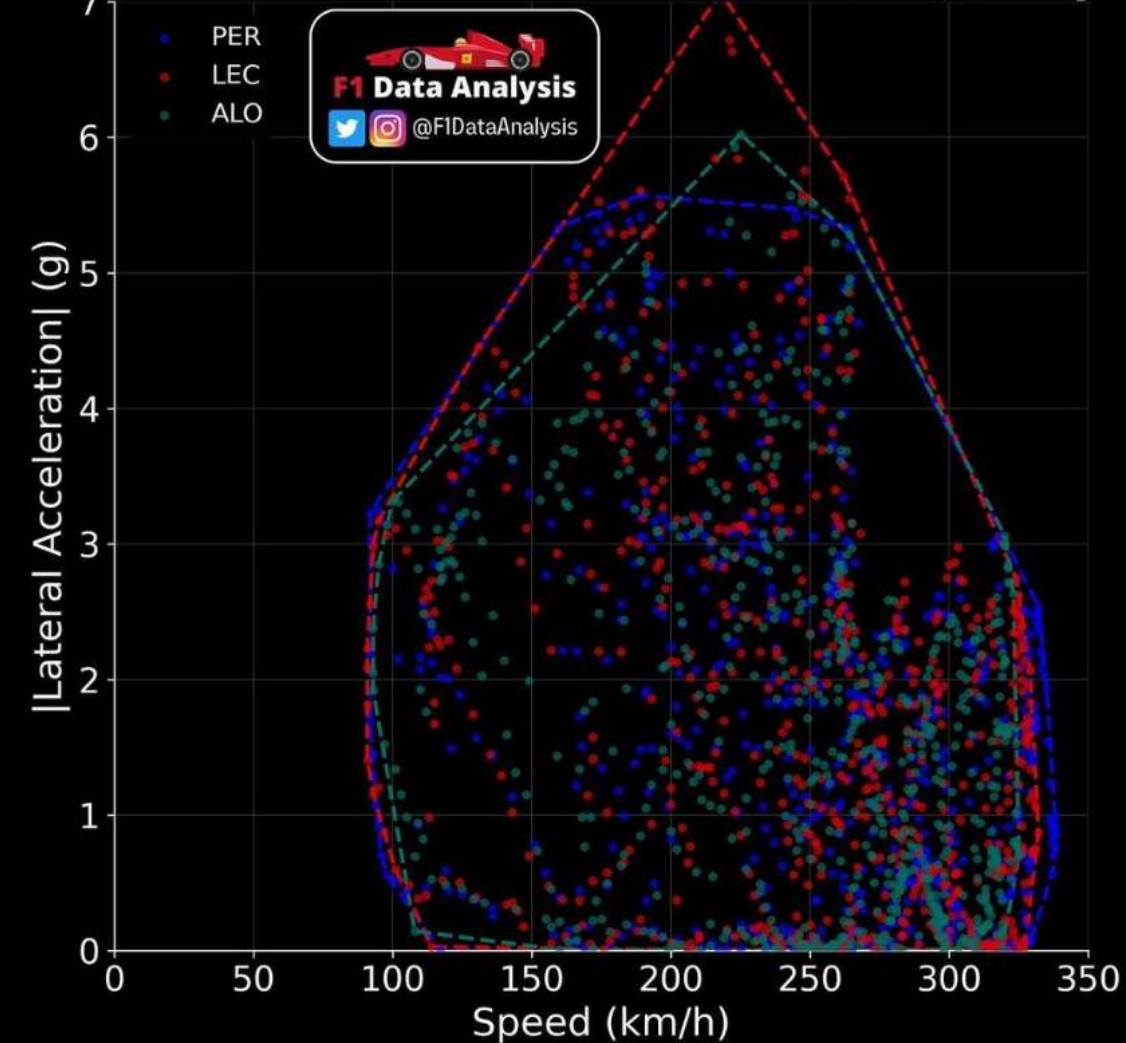
- GGV diagram
- Lateral WT Magic number
- Brake system calculation

2023 Saudi Arabian Grand Prix - Qualifying

- Normally much higher braking than traction ability
- Lateral behaviour: track->setup (assymetric cambers?)
- Average acceleration

2023 Saudi Arabian Grand Prix - Qualifying

- Normally much higher braking than traction ability
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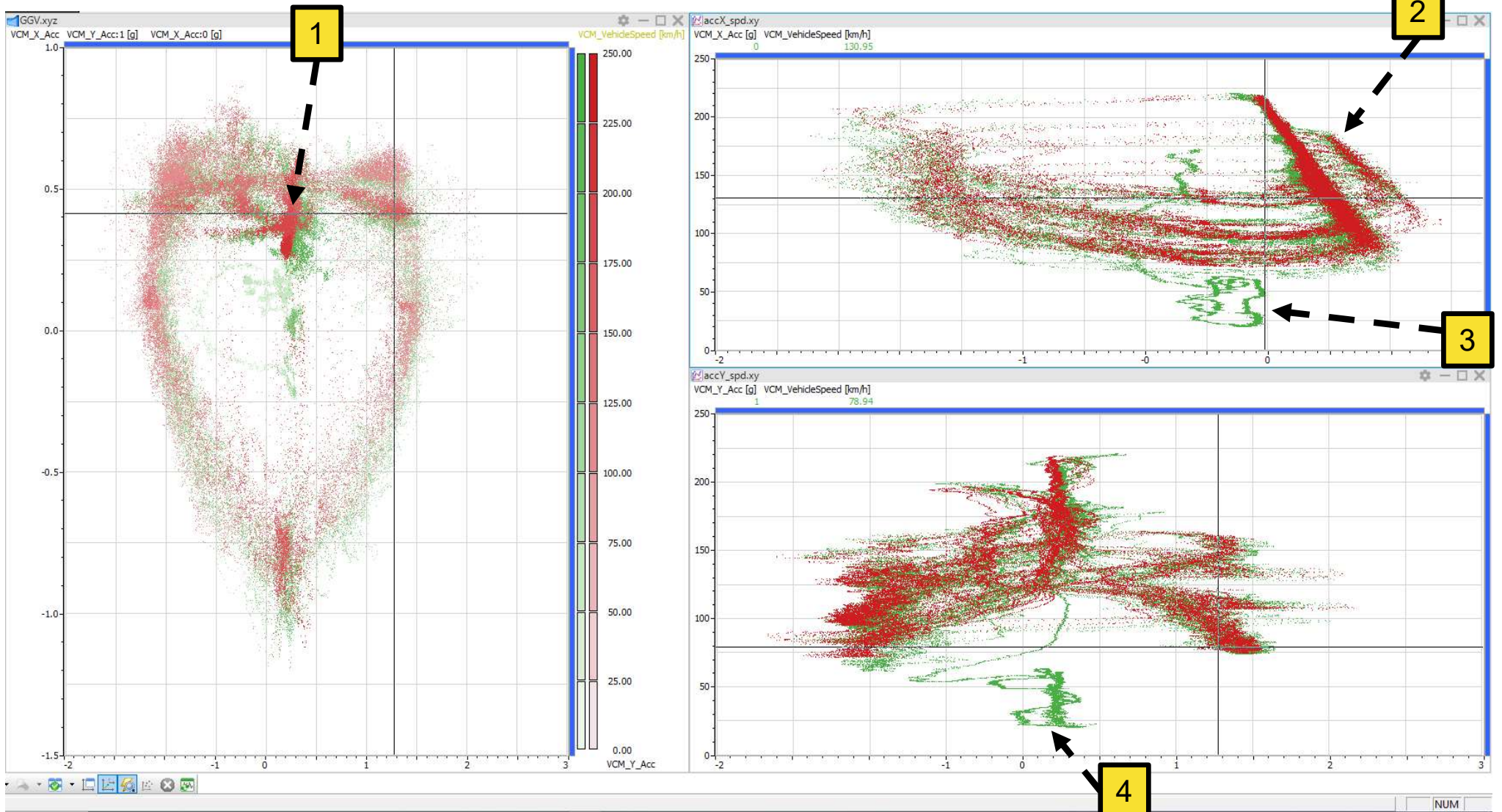- Average acceleration

GGV diagram
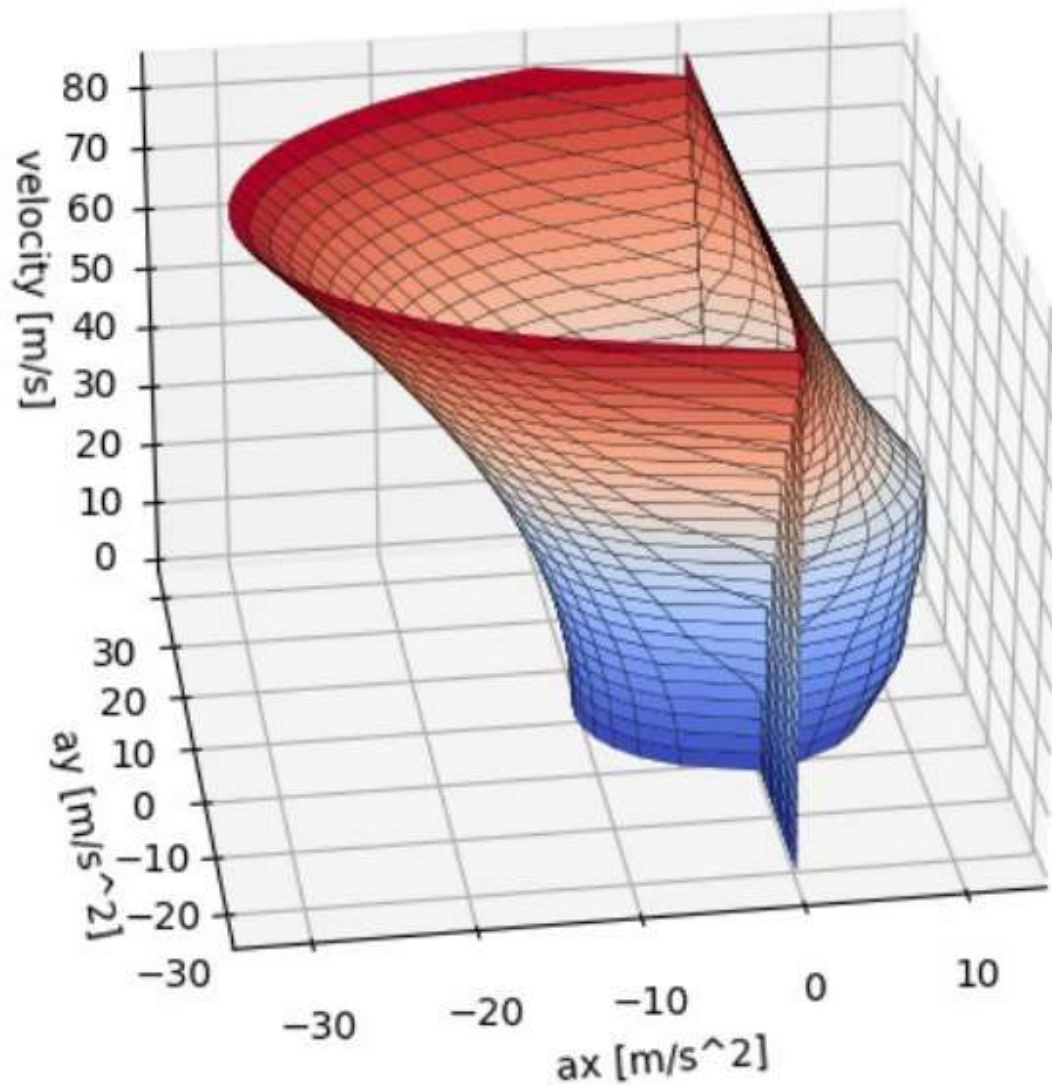
- Missing part: lack of acceleration, lack of power
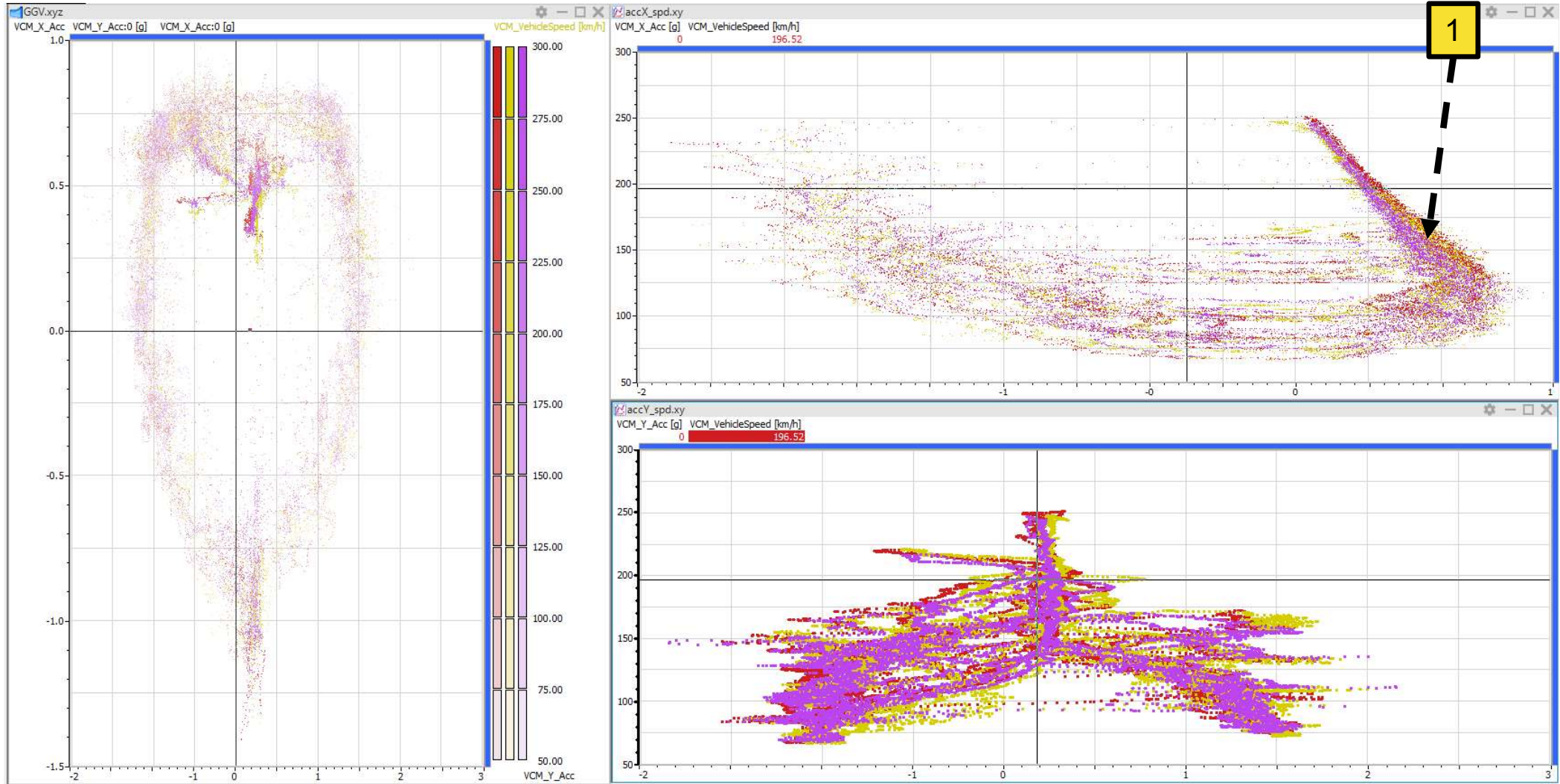- More theortetical envelop than measured data

High speed corner left or right?

High speed corner left or right?

Static weight distribution   Weight transfer during a corner

370 | 370   220 | 520
----   ----
260 | 260   60 | 460

1. Total weight of the car?
2. WT Magic number' for the given example?
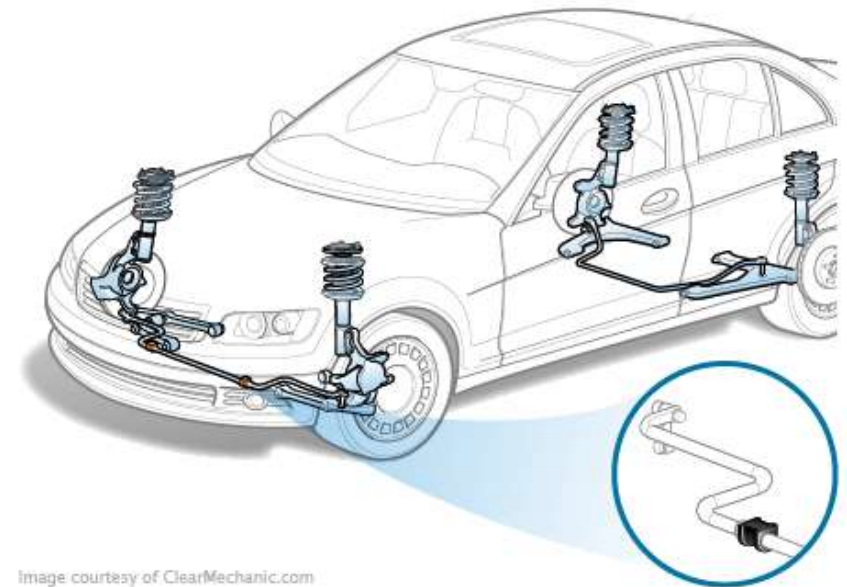3. We put stiffer rear ARB by 3%, what will be the WD for the same situation?

Image courtesy of ClearMechanic.com

Static weight distribution   Weight transfer during a corner

$$\begin{array}{c|c} 370 & 370 \\ \hline 260 & 260 \end{array}$$

$$\begin{array}{c|c} 220 & 520 \\ \hline 60 & 460 \end{array}$$

1. Total weight of the car? (370+260)*2=1260 kg

Image courtesy of ClearMechanic.com
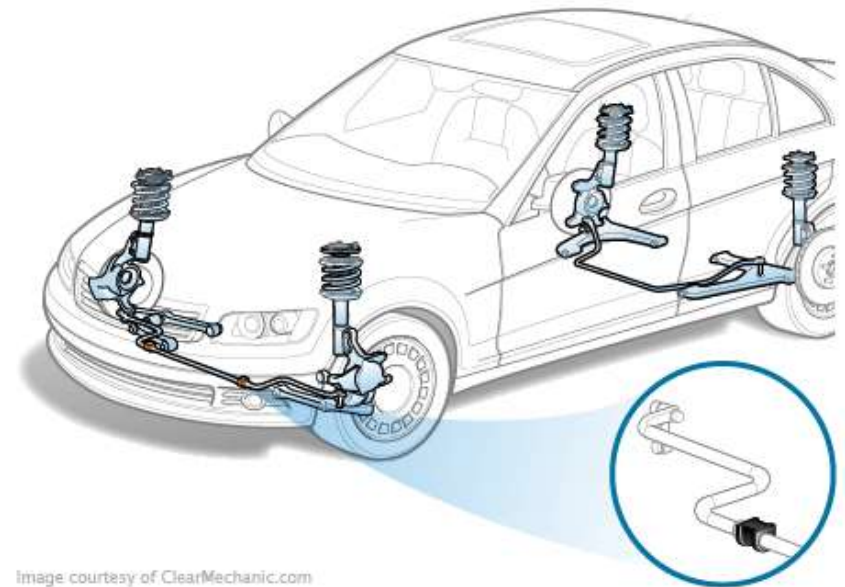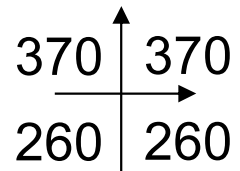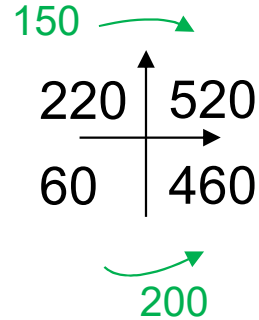
Static weight distribution

Weight transfer during a corner

150

$$\begin{array}{c|c} 370 & 370 \\ \hline 260 & 260 \end{array}$$

$$\begin{array}{c|c} 220 & 520 \\ \hline 60 & 460 \end{array}$$

200

2. WT Magic number' for the given example?

150/(150+200)= 42,86 %

Image courtesy of ClearMechanic.com

Static weight distribution   Weight transfer during a corner

$$\begin{array}{c|c} 370 & 370 \\ \hline 260 & 260 \end{array}$$ $$\begin{array}{c|c} 220 & 520 \\ \hline 60 & 460 \end{array}$$

3. We put stiffer rear ARB by 3%, what will be the WD for the same situation?
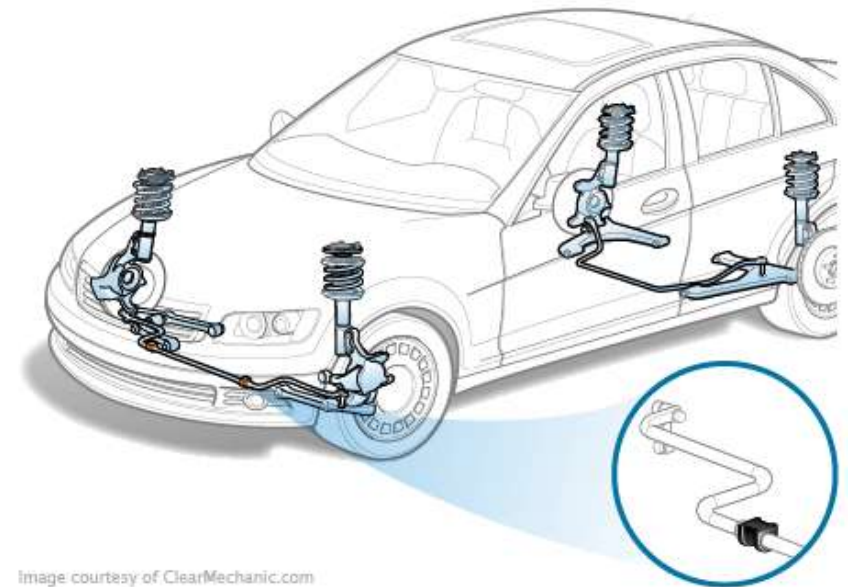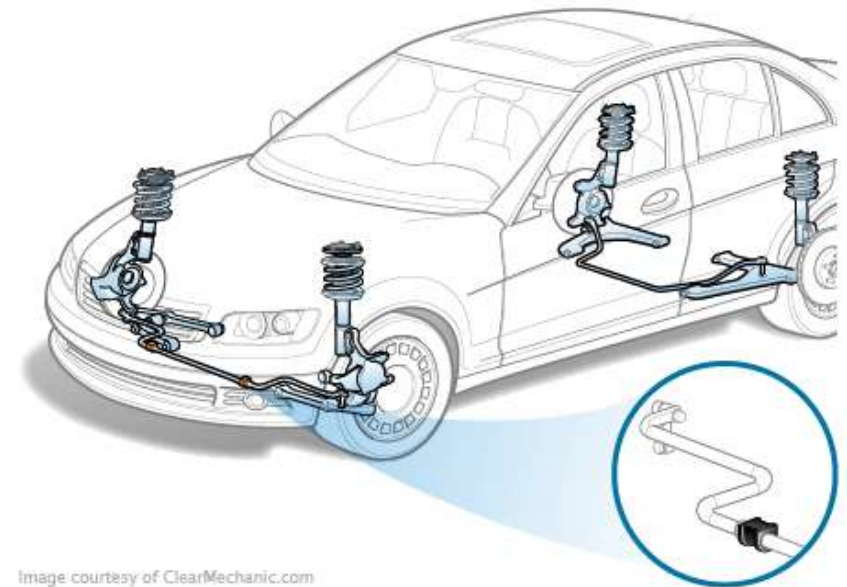

Image courtesy of ClearMechanic.com

Static weight distribution

$$\frac{370 \;|\; 370}{260 \;|\; 260}$$

Weight transfer during a corner

$$\frac{220 \;|\; 520}{60 \;|\; 460}$$

3. We put stiffer rear ARB by 3%, what will be the WD for the same situation? 42,86 % - 3%= 39,86%

Image courtesy of ClearMechanic.com

Static weight distribution

Weight transfer during a corner

$$370 \mid 370$$
$$260 \mid 260$$

$$220 \mid 520$$
$$60 \mid 460$$

3. We put stiffer rear ARB by 3%, what will be the WD for the same situation? 42,86 % - 3%= 39,86%

$$\frac{x}{350} = 39,86 \%$$

$$x = 139,51 \ kg$$

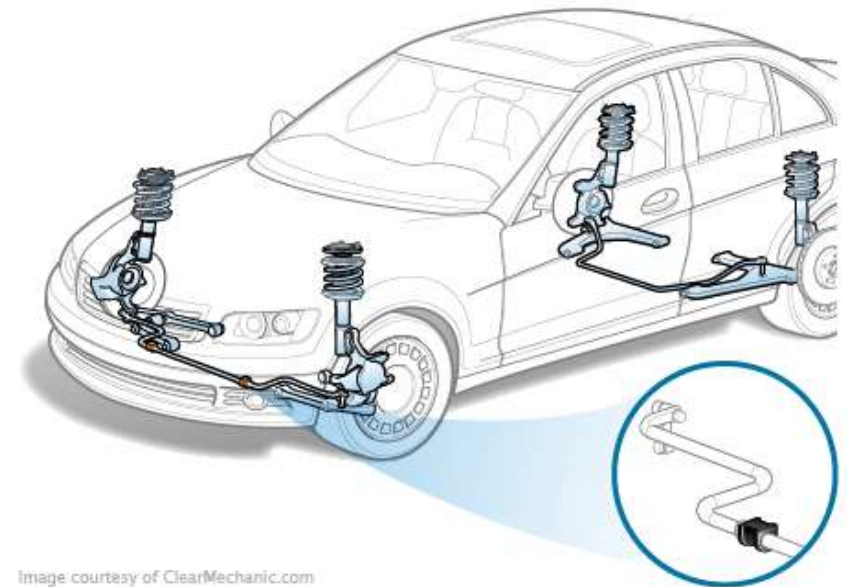Static weight distribution

$$
\begin{array}{c|c}
370 & 370 \\
\hline
260 & 260
\end{array}
$$

Weight transfer during a corner

$$
\begin{array}{c|c}
220 & 520 \\
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$$

3. We put stiffer rear ARB by 3%, what will be the WD for the same situation? 42,86 % - 3%= 39,86%

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$$
\begin{array}{c|c}
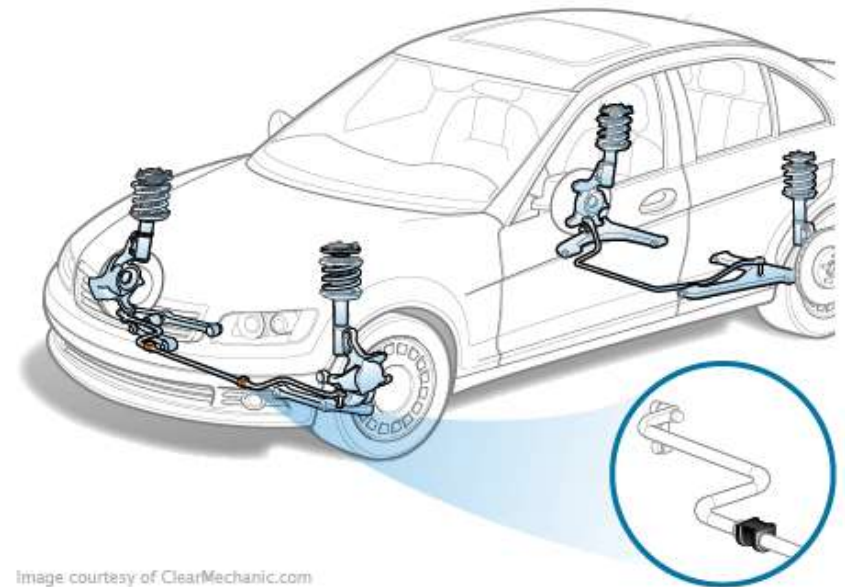230,49 & 509,51 \\
\hline
49,51 & 470,49
\end{array}
$$

Image courtesy of ClearMechanic.com

Static weight distribution

$$\begin{array}{c|c} 370 & 370 \\ \hline 260 & 260 \end{array}$$

Weight transfer during a corner

$$\begin{array}{c|c} 370 & 370 \\ \hline 260 & 260 \end{array}$$

1. Total weight of the car?
2. WT Magic number' for the given example?
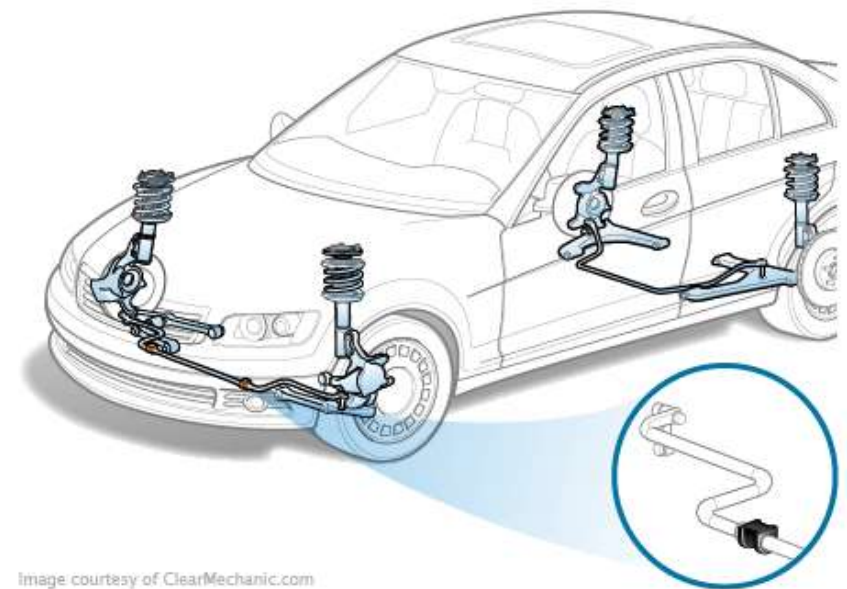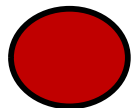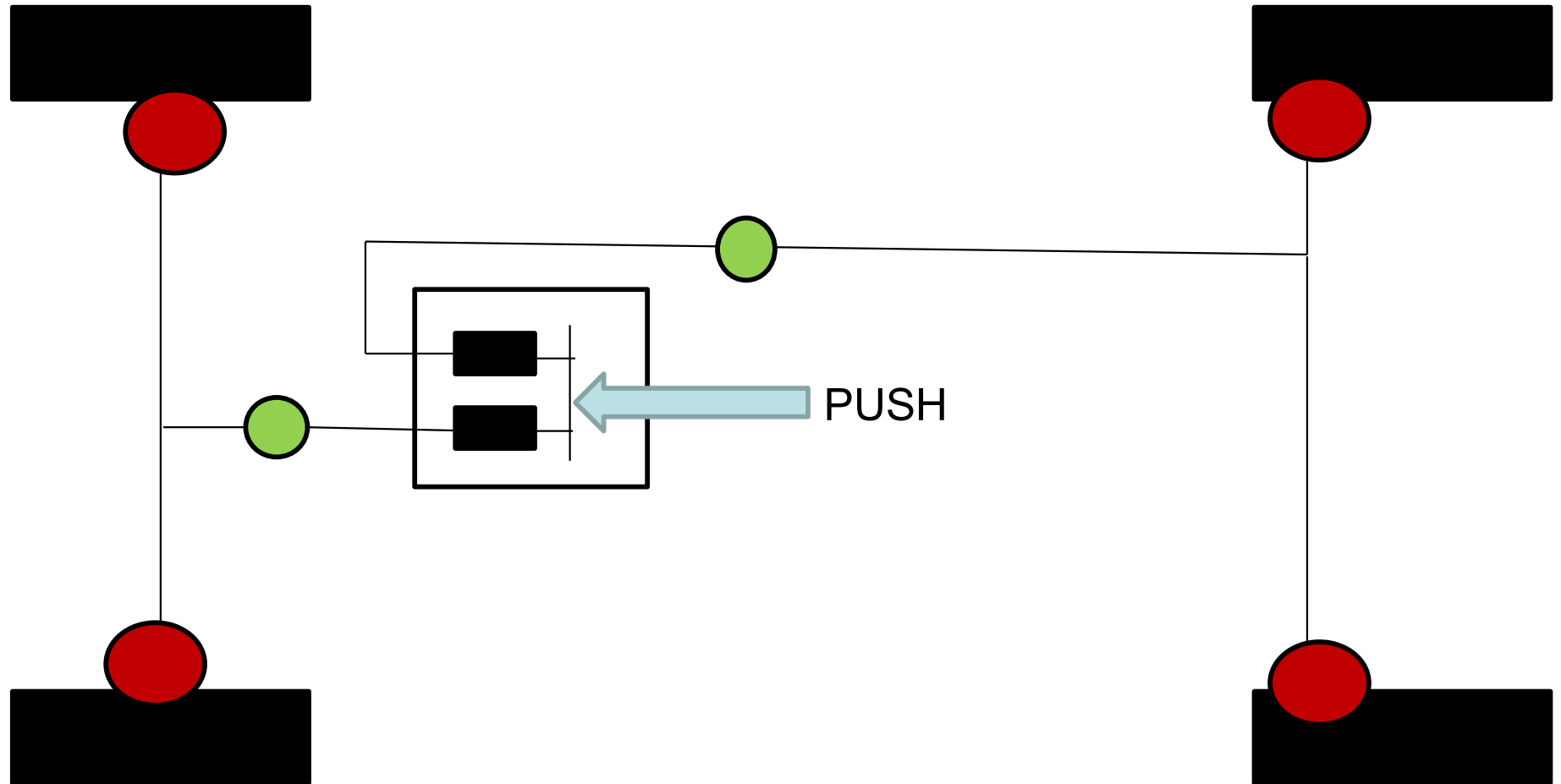3. We put stiffer rear ARB by 3%, what will be the WD for the same situation

image courtesy of ClearMechanic.com

Brake system

Calipers   Brake pressure sensor

Brake system

Caliper

PUSH

Brake system - input

Balance bar

Master cylinder

133 lb to front m/c 117 lb to rear m/c

A

1.40" 1.60"

250 lb from brake pedal

Piston Rod

Extension stroke

Pump flow Piston seal Return flow

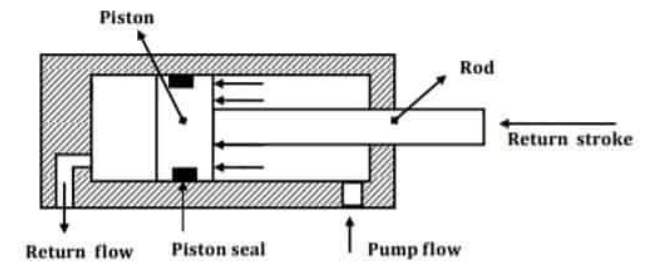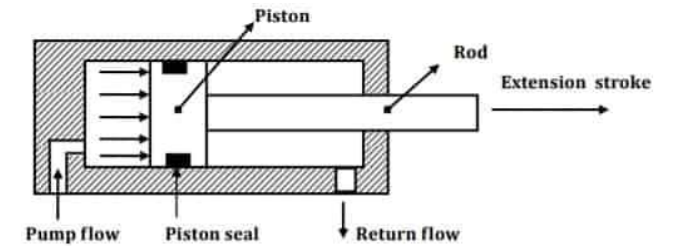Piston

Rod

Return stroke

Return flow Piston seal Pump flow
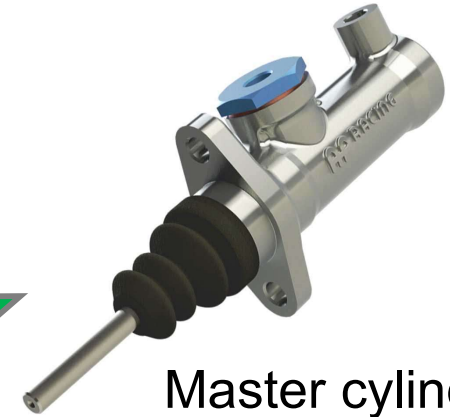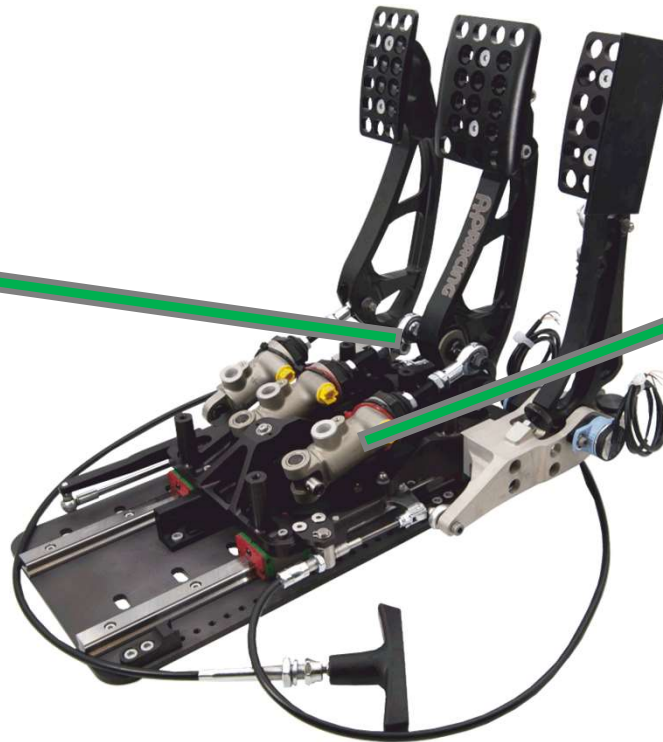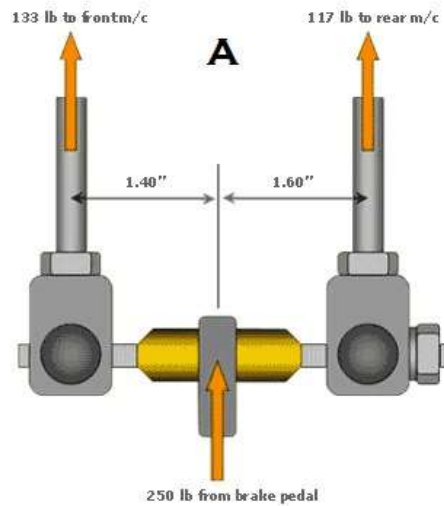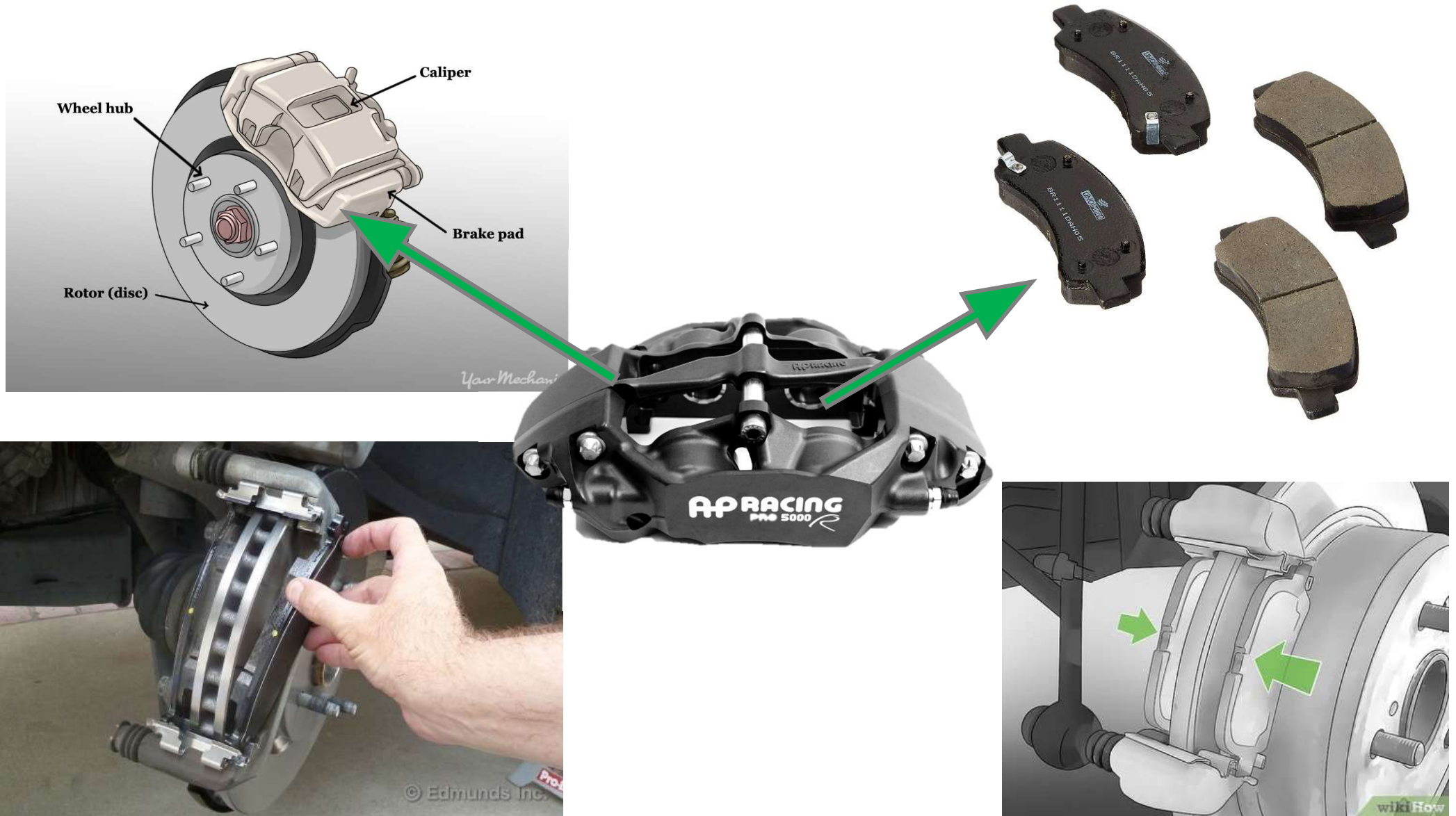
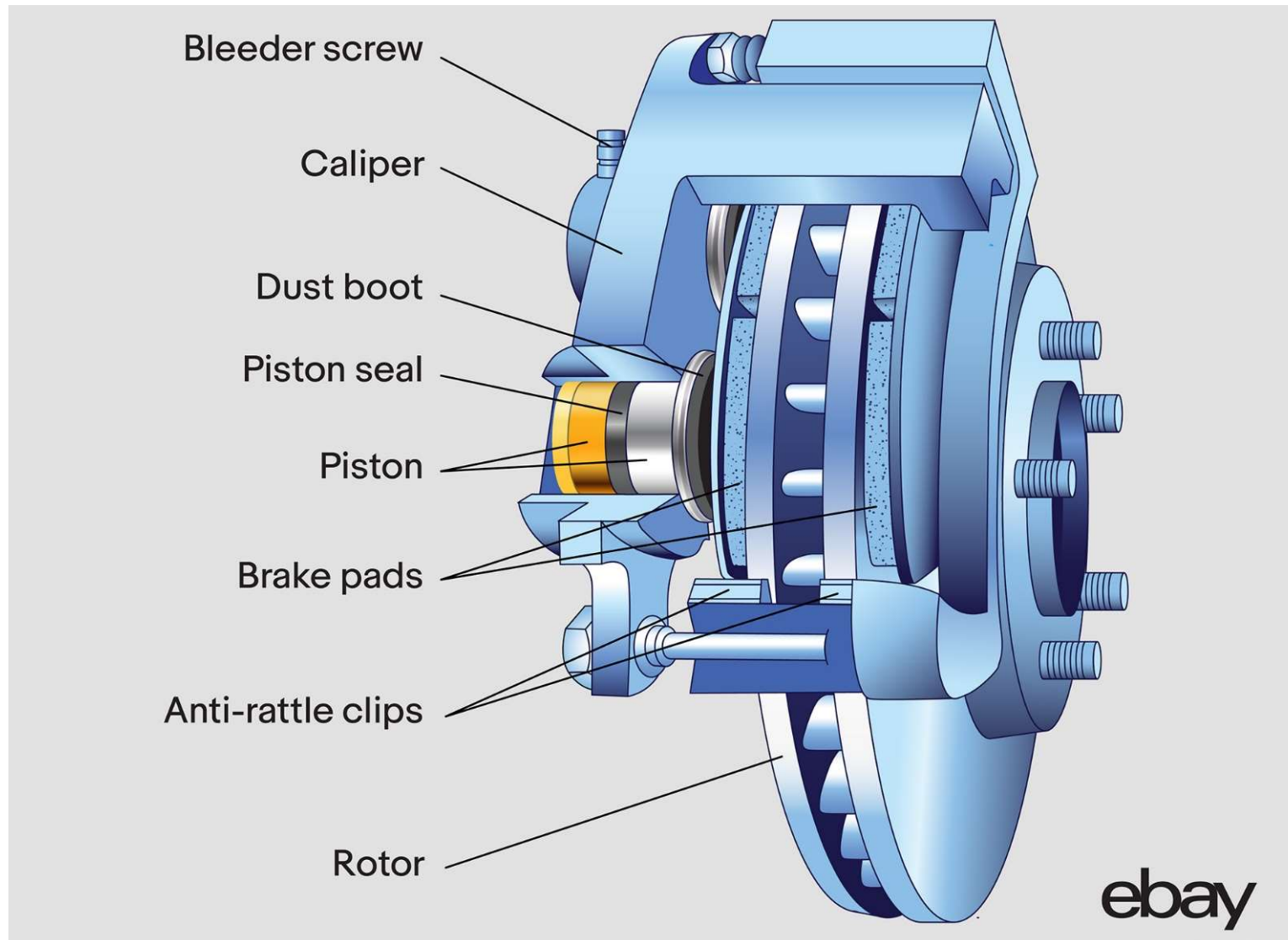Figure 1.4 Double-acting cylinder with a piston rod on one side

Brake system - output

Brake system - output

Bleeder screw
Caliper
Dust boot
Piston seal
Piston
Brake pads
Anti-rattle clips
Rotor

ebay

Brake system - parameters

F_1 – Force by foot of driver
r_1 - Ratio of balance bar
$A_{1F/R}$ – Area of piston F/R
$p_{1F/R}$ – Pressure in the piston F/R

F_2 – Force at the pads
$A_{2F/R}$ – Area of piston F/R
$p_{2F/R}$ – Pressure at the caliper F/R

A_1, F_1, p_1

A_2, F_2, p_2

PUSH

$$p = \frac{F}{A} \qquad p_1 = p_2 = \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

Brake system - parameters

F_1 – Force by foot of driver
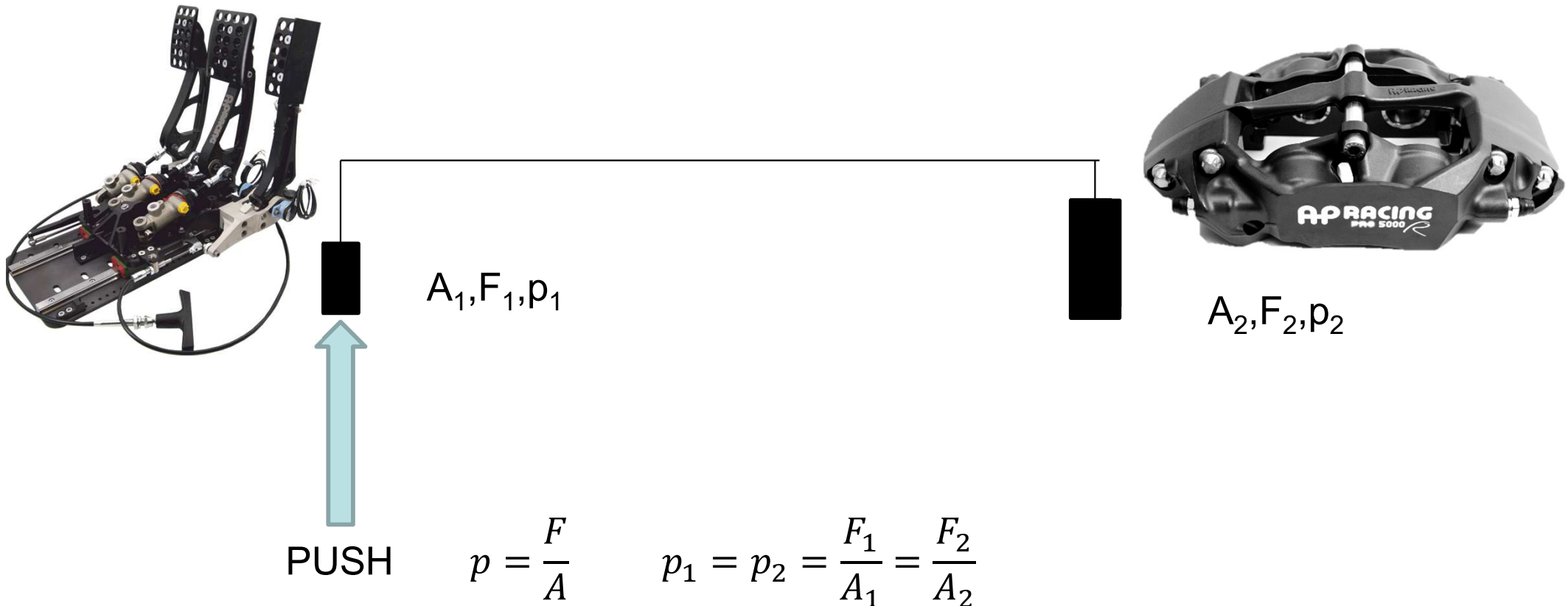r_1 - Ratio of balance bar
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F_2 – Force at the pads
$A_{2F/R}$ – Area of piston F/R
$p_{2F/R}$ – Pressure at the caliper F/R

PUSH

Questions
a) Is $p_{1F}=p_{2F}$?
b) Is $p_{1R}=p_{2R}$?

Brake system - parameters

F_1 – Force by foot of driver
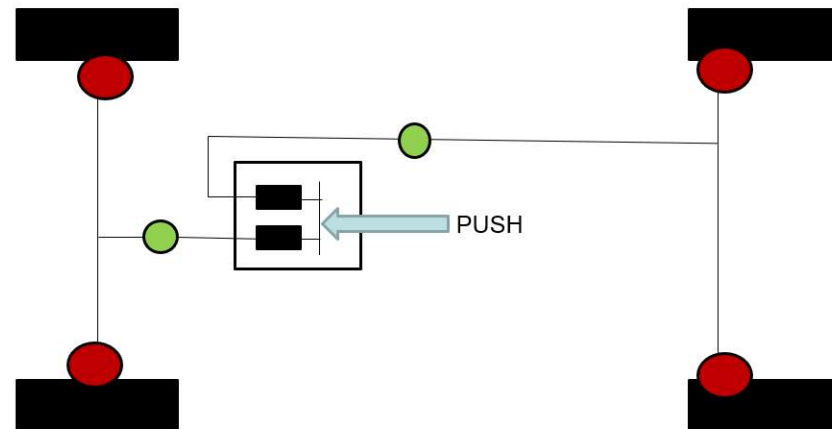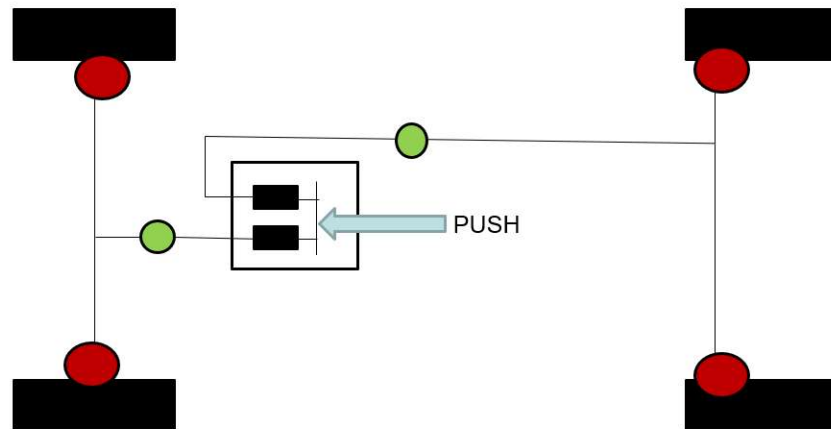r_1 - Ratio of balance bar
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F_2 – Force at the pads
$A_{2F/R}$ – Area of piston F/R
$p_{2F/R}$ – Pressure at the caliper F/R

PUSH

Questions
a) Is $p_{1F} = p_{2F}$?
b) Is $p_{1R} = p_{2R}$?

$$p = \frac{F}{A} \qquad p_1 = p_2 = \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

Brake system - parameters

F_1 – Force by foot of driver
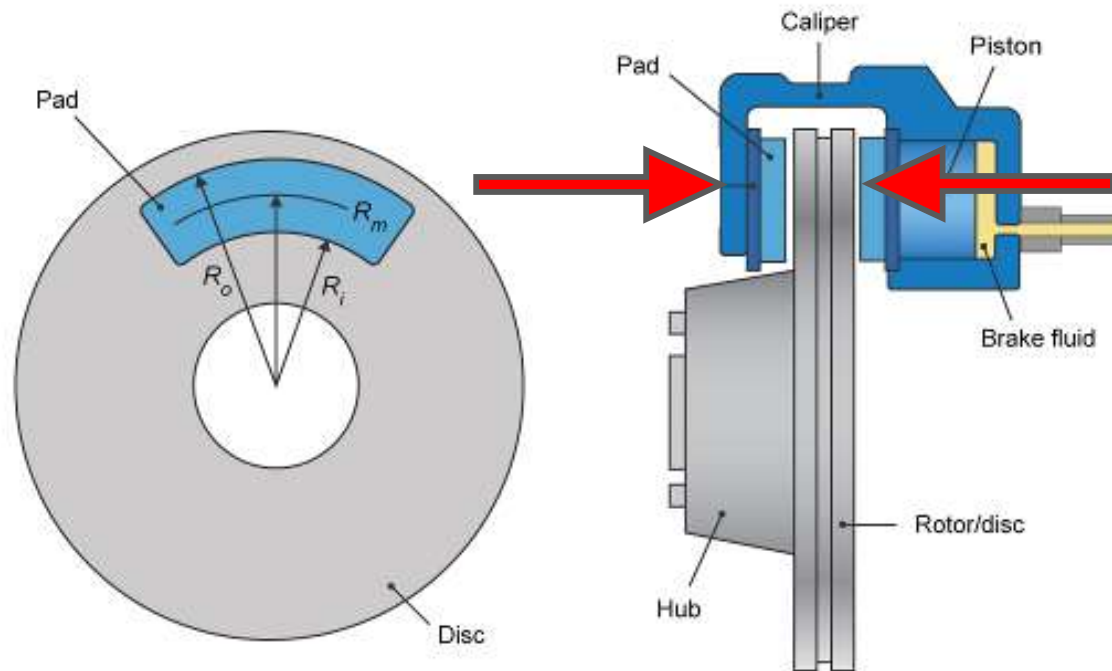r_1 - Ratio of balance bar
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$A_{2F/R}$ – Area of piston F/R
$p_{2F/R}$ – Pressure at the caliper F/R

Brake system - parameters

F_1 – Force by foot of driver
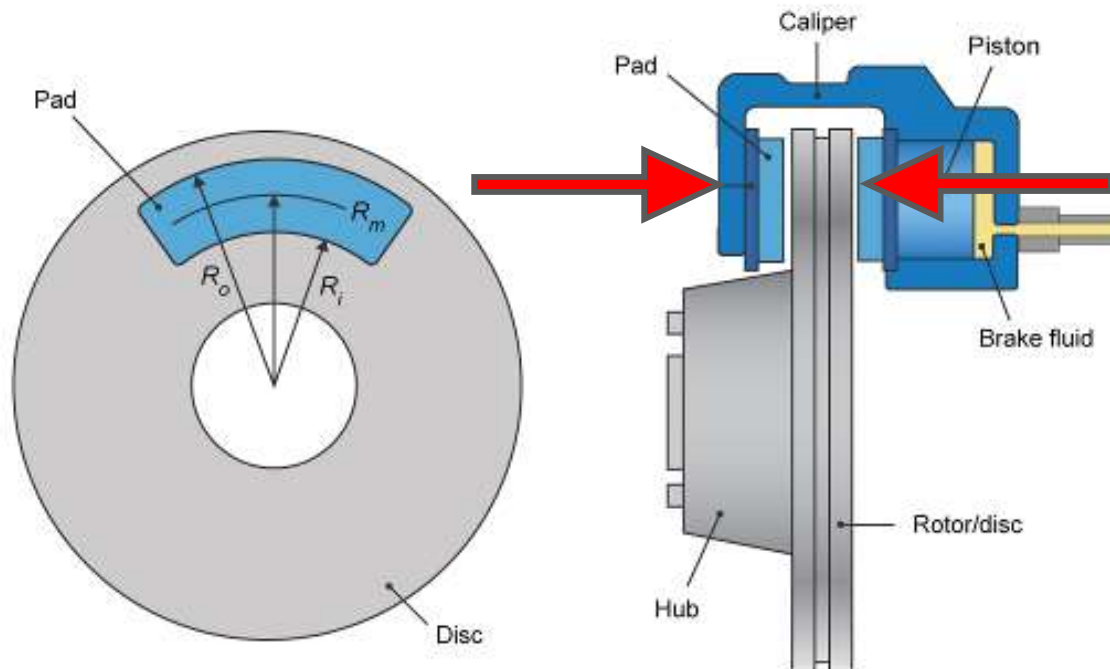r_1 - Ratio of balance bar
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Questions
a) What else is necessary to know the braking torque?

Brake system - parameters

F_1 – Force by foot of driver
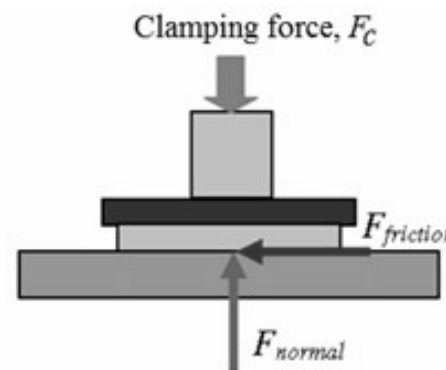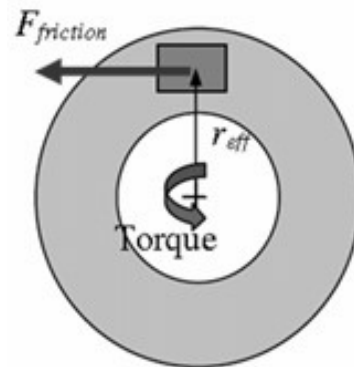r_1 - Ratio of balance bar
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$p_{2F/R}$ – Pressure at the caliper F/R

Questions
a) What else is necessary to know the braking torque? Coefficient of friction, radius.

Calc example! Design racecar's brake system!

F_{foot} – 300 N
L_1 – 147 mm
L_2 – 93 mm
r_{mc} – 25 mm
μ_{pad} – 0,61
μ_{road} – 0,85
r_c – 30 mm
r_d – 150 mm
r_{pad} – 130 mm
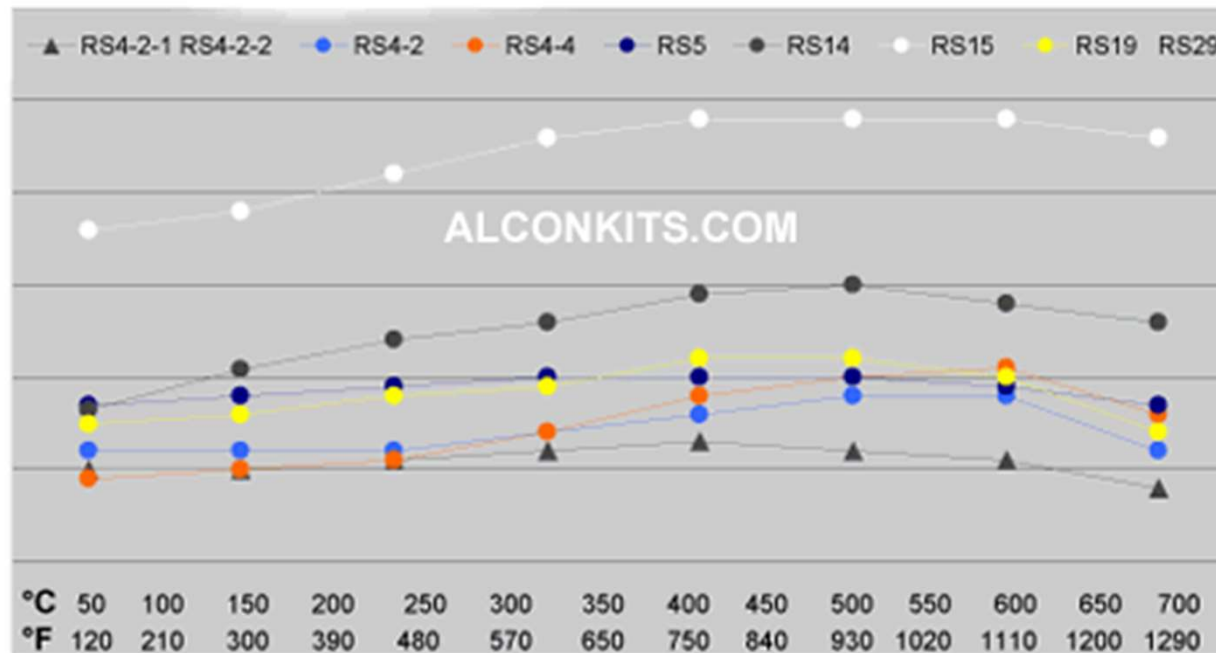
Questions:
1. What is the braking force ($F_{x,b}$) that can appear at the contact patch? ~373,0 N
2. What is the necessary normal force that is required to use this entire braking force? ~438,9 N

F_{foot}

L_1 L_2

r_{mc}

F_{mc}

p

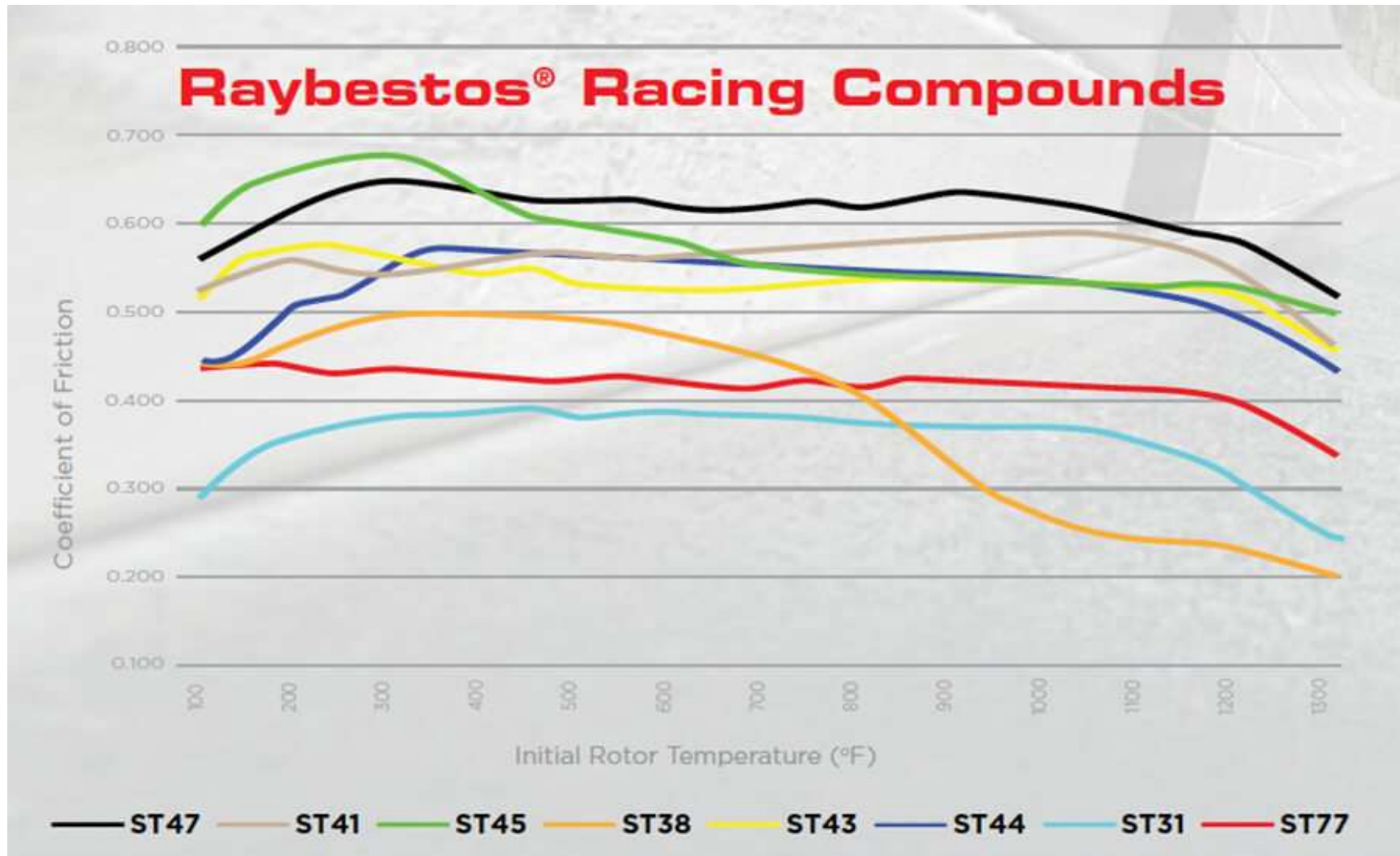μ_{pad} $F_{x,b}$

r_c

F_c

μ_{road}
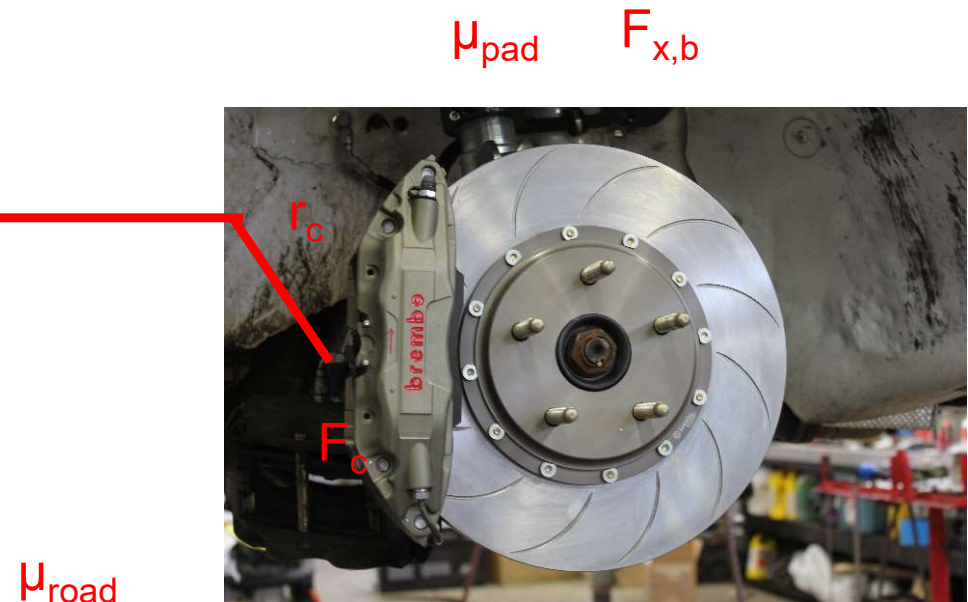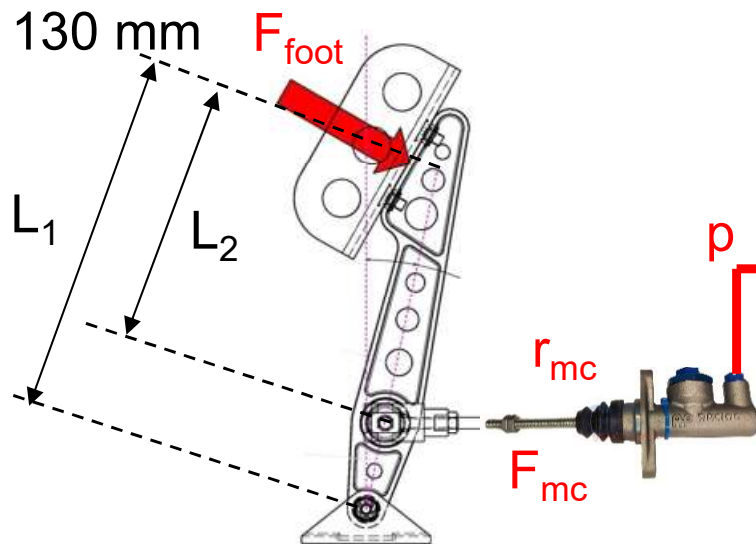
Brake system

PAGID Friction and Temperature profile provided by AlconKits.com

Friction vs Temperature Graph

Brake system

Bibliography

- https://www.google.com/search?q=balance+bar+bias&tbm=isch&ved=2ahUKEwiD_MXK4vz9AhXdxgIHHbb_C6sQ2-cCegQIABAA&oq=balance+bar+bias&gs_lcp=CgNpbWcQAzoECCMQJzoICAAQBxAeEBM6CAgAEAgQHhATOgcIABCKBRBDOggIABCABBCxAzoLCAAQgAQQsQMQgwE6BAgAEAM6CggAEIoFELEDEEM6BQgAEIAEOgcIABCABBATOggIABAFEB4QEzoGCAAQHhATOgQIABAeOgYIABAFEB5Q9gVYkx1gix5oAXAAeACAAVSIAbIKkgECMTiYAQCgAQGqAQtnd3Mtd2l6LWltZ8ABAQ&sclient=img&ei=h-QhZMOcEt2Ni-gPtv-v2Ao&bih=1052&biw=2133#imgrc=15ZQ10PybQuouM&imgdii=yAPeL5iEGhmVsM
- https://www.wikihow.com/Change-a-Brake-Caliper
- https://www.edmunds.com/how-to/how-to-change-your-brake-pads.html
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- https://www.researchgate.net/figure/Brake-torque-model-in-contact-interface-a-top-view-b-front-view_fig4_264437590
- https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.linkedin.com%2Fpulse%2Frace-car-pedal-study-iv%25C3%25A1n-platas&psig=AOvVaw3QEye-wdMXkYOTgeS-fOmq&ust=1709026308173000&source=images&cd=vfe&opi=89978449&ved=0CBIQjRxqFwoTCPjP6aHZyIQDFQAAAAAdAAAAABAZ

Thank you for your attention!