Errata and Addenda for the Book
The Science of Vehicle Dynamics
2nd edition
first printing (2018)
second (corrected) printing (2019)

Massimo Guiggiani

July 27, 2022

These are all the errors and omissions for the **first printing** of the book *The Science of Vehicle Dynamics* (2nd ed.), published by Springer in 2018, reported as of **July 27, 2022**.

Errors and additional material are listed here in two ways:

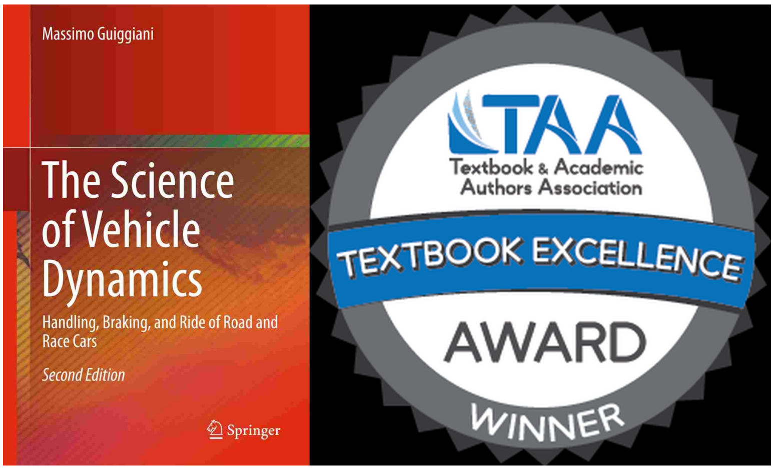
- by page number (better for first reading), right hereafter;
- in chronological order (better for updating), beginning on page 12.

Positions in the book are indicated by page and line number, where the top line of a page is number 1 and the bottom line is number −1. A running head and a page number are not considered to be lines, but all other lines are.

Errors found until **February 15, 2019** were corrected in the **second printing**. You have a second printing copy if you see "corrected publication" on page iv, line 11.

Please report any additional error to `massimo.guiggiani@unipi.it`

Updates will be available at `www.dimnp.unipi.it/guiggiani-m/SVDErrata_2nd.pdf`



2019 Textbook Excellence Award motivation: *The Science of Vehicle Dynamics is a masterful text written by an exceptional contributor in the field of applied mathematics. Students and professionals alike will benefit from this practical yet innovative treatment of the material, which has already impacted the industry.*"

Errata and addenda ordered by page number

Chapter 1 - Introduction

Chapter 2 - Mechanics of the Wheel with Tire

Ch. 2, page 14, eqn. (2.7)

The correct equation is as follows

$$\begin{aligned}\mathbf{V}_o &= V_{o_x}\mathbf{i} + V_{o_y}\mathbf{j}\\ &= V_{o_x}(\mathbf{i} - \tan\alpha\mathbf{j})\end{aligned}$$

[First reported by *Emanuele Di Pino* on 10 October 2019]

Ch. 2, page 16, line 1

Insert ($d_t < 0$) at the end of the caption.
[First reported by *Massimo Guiggiani* on 25 October 2019]

Ch. 2, page 23, last line

"trailing rolling" should be "tractive rolling"
[First reported by *Stylianos (Stelios) Markolefas* on 4 September 2019]

Ch. 2, page 50, line −9

Replace 15 with 18.
[First reported by *Marco Gabiccini* on 5 September 2018]

Ch. 2, page 52, line −4

Replace σ_x with σ_y.
[First reported by *Shaid Farzand* on 20 September 2018]

Ch. 2, page 54, Fig. 2.36

Curves are for different values of σ_y, not of σ_x.
[First reported by *Marco Gabiccini* on 6 September 2018]

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Insert a minus sign in front of 1100.
[First reported by *Marco Gabiccini* on 6 September 2018]

Ch. 2, page 62, line 2

Insert a minus sign in front of 1100.
[First reported by *Marco Gabiccini* on 6 September 2018]

Chapter 3 - Vehicle Model for Handling and Performance

Ch. 3, page 87, line 1

Add "and $\delta_1^0 = 0$" inside the parentheses.
[First reported by *Massimo Guiggiani* on 13 May 2020]

Ch. 3, page 89, lines 22–31

IMPORTANT
In these lines there are several errors. The correct text is as follows:

If the vehicle has *parallel steering*, in case (a), it is the front outer wheel to have a bigger slip angle than the front inner wheel. In case (b), both front wheels have the same slip angle. In case (c), which is quite frequent in race cars, it is the front inner wheel to have the bigger slip angle.

If the vehicle has *positive Ackermann correction* ($\varepsilon_1 > 0$), that is dynamic toe-out, the inner wheel has the bigger slip angle not only in case (c), but also in case (b) and in a small fraction of case (a).

With *negative Ackermann correction* ($\varepsilon_1 < 0$), that is dynamic toe-in, it is the other way around. The inner wheel has the bigger slip angle only in part of case (c).
[First reported by *Shaid Farzand* on 28 October 2018]

Ch. 3, page 102, line −7

Replace < 0 with > 0.
[First reported by *Andrea Quintarelli* on 30 June 2019]

Ch. 3, page 103, eqn. (3.101)

Delete the last "=".
[First reported by *Shaid Farzand* on 28 October 2018]

Ch. 3, page 138, eqn. (3.186)

The correct form is

$$\zeta = \frac{\arctan(\chi \Delta\hat{\omega}\, \mathrm{sign}(M_h))}{\pi/2}$$

[First reported by *Lorenzo Bartali* on 25 June 2021]

Ch. 3, page 160, lines 2 and 3

Replace Q_G with E_G.
[First reported by *Shaid Farzand* on 28 October 2018]

Chapter 4 - Braking Performance

Ch. 4, page 173, eqn. (4.15) - ADDENDUM

Optimal brake balance with front to rear different grip (no aero loads)

Let μ_1 be the coefficient of friction of the front axle, and μ_2 be the coefficient of friction of the rear axle.

Then, the optimal brake balance β_P is given by

$$\beta_P = \frac{X_{1_P}}{X_{2_P}} = \frac{\mu_1(a_2 + h\mu_2)}{\mu_2(a_1 - h\mu_1)}$$

that generalizes (4.15)
[First reported by *Massimo Guiggiani* on 22 June 2020]

Ch. 4, page 180, eqn. (4.30)

Flip the sign of the term on the r.h.s., thus obtaining

$$u(t) = u_d \tan\left(\arctan\left(\frac{u_0}{u_d}\right) - \frac{t}{t_d}\right)$$

[First reported by *Tommaso Bugliesi* on 1 October 2019]

Ch. 4, page 181 – ADDENDUM

Optimal practical brake balance for Formula cars

As commonly done by race engineers, in addition to the brake balance $\beta = X1/X2$, we define the *practical brake balance* η

$$\eta = \frac{X_1}{X_1 + X_2}$$

along with the *weight distribution* ω

$$\omega = \frac{Z_1^0}{Z_1^0 + Z_2^0} = \frac{a_2}{a_1 + a_2}$$

and the *aero balance* α

$$\alpha = \frac{C_{z_1}}{C_{z_1} + C_{z_2}} = \frac{\zeta_1}{\zeta_1 + \zeta_2} = \frac{\zeta_1}{\zeta}$$

where $\zeta = \zeta_1 + \zeta_2$.

We obtain the following result for the *optimal* practical brake balance η_p

$$\eta_p = \frac{mg(\mu\frac{h}{l} + \omega) + \zeta u^2(\mu\frac{h}{l} + \alpha) + \xi u^2 \frac{h}{l}}{mg + \zeta u^2}$$

which is the counterpart of (4.35). Of course, in general, η_p is speed dependent.

To avoid speed dependence of η_p (like in Fig. 4.11), it must be $\partial\eta_p/\partial u = 0$, that means

$$(\omega - \alpha)\zeta - \frac{h}{l}\xi = 0$$

or, equivalently

$$(\omega - \alpha)C_z - \frac{h}{l}C_x = 0$$

which can be rewritten as

$$\omega = \alpha + \frac{C_x}{C_z}\frac{h}{l}$$

These last three equations are the counterpart of (4.37). We see that, to avoid speed dependence of η_p, it is necessary that $\omega > \alpha$, but just a little. For instance, in a Formula car, it results $\omega - \alpha \simeq 0.02$.

Sensitivity of the optimal practical brake balance η_p with respect to aero balance α

$$\frac{\partial\eta_p}{\partial\alpha} = \frac{\zeta u^2}{mg + \zeta u^2}$$

Very simple formula. No μ, no h/l, no C_x. Strong speed dependence at high speed.

Sensitivity of the optimal practical brake balance η_p with respect to weight distribution ω

$$\frac{\partial \eta_p}{\partial \omega} = \frac{mg}{mg + \zeta u^2}$$

Very simple formula. No μ, no h/l, no C_x. Strong speed dependence at low speed.
[First reported by *Massimo Guiggiani* with *Ernesto Desiderio* on 6 May 2020]

Ch. 4, page 181 - ADDENDUM

Optimal practical brake balance for Formula cars with front to rear different grip

Let μ_1 be the coefficient of friction of the front axle, and μ_2 be the coefficient of friction of the rear axle.

Then, the optimal practical brake balance η_p is given by

$$\eta_p = \frac{X_{1_P}}{X_{1_P} + X_{2_P}} = \frac{\mu_1 \left[mg(\mu_2 \frac{h}{l} + \omega) + \zeta u^2 (\mu_2 \frac{h}{l} + \alpha) + \xi u^2 \frac{h}{l} \right]}{mg[\mu_1 \omega + \mu_2 (1-\omega)] + \zeta u^2 [\mu_1 \alpha + \mu_2 (1-\alpha)] + \xi u^2 \frac{h}{l} (\mu_1 - \mu_2)}$$

[First reported by *Massimo Guiggiani* with *Federico Sánchez Motellón* on 22 June 2020]

Ch. 4, page 185, line −13

300/3.6 is equal to 83.33
[First reported by *Daniele Duranti* on 1 October 2019]

Chapter 5 - The Kinematics of Cornering

Ch. 5, page 195, line −2

Delete ”radius of curvature”.
[First reported by *Cesare Certosini* on 12 February 2019]

Ch. 5, page 196, line −1

Replace $\hat{be}_1$ with $\hat{\beta}_1$.
[First reported by *Daniele Duranti* on 26 July 2019]

Ch. 5, page 197, line 16

Replace centerthe with center, but only in the pdf edition!
[First reported by *Simone Vollaro* on 11 August 2020]

Ch. 5, page 204, eqn. (5.25), second line

Should be $-\dot{S}$
[First reported by *Eleonora D'Ortenzi and Marta Bartalesi* on 5 April 2019]

Ch. 5, page 204, eqn. (5.25), second line

The first denominator should be r^2, consistently with the first line.
[First reported by *Massimo Guiggiani* on 4 September 2018]

Ch. 5, page 210, line 10

"Evolute" is doubled.
[First reported by *Daniele Duranti* on 26 July 2019]

Ch. 5, page 211, line 1

Replace rad/s^2 with rad/s.
[First reported by *Daniele Duranti* on 26 July 2019]

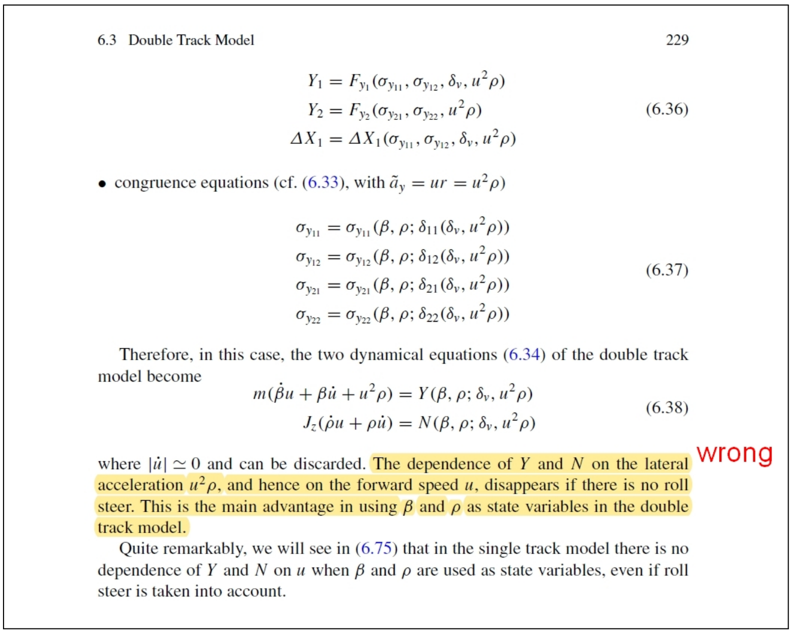
Chapter 6 - Handling of Road Cars

Ch. 6, page 215, line 14

(3.85) should be (3.84)
[First reported by *Stylianos (Stelios) Markolefas* on 4 September 2019]

Ch. 6, pages 229, 248, 286

IMPORTANT
In these pages there are some errors, as explained hereafter:



6.3 Double Track Model 229

$$\begin{aligned} Y_1 &= F_{y_1}(\sigma_{y_{11}}, \sigma_{y_{12}}, \delta_v, u^2\rho) \\ Y_2 &= F_{y_2}(\sigma_{y_{21}}, \sigma_{y_{22}}, u^2\rho) \\ \Delta X_1 &= \Delta X_1(\sigma_{y_{11}}, \sigma_{y_{12}}, \delta_v, u^2\rho) \end{aligned} \tag{6.36}$$

- congruence equations (cf. (6.33), with $\tilde{a}_y = ur = u^2\rho$)

$$\begin{aligned} \sigma_{y_{11}} &= \sigma_{y_{11}}(\beta, \rho; \delta_{11}(\delta_v, u^2\rho)) \\ \sigma_{y_{12}} &= \sigma_{y_{12}}(\beta, \rho; \delta_{12}(\delta_v, u^2\rho)) \\ \sigma_{y_{21}} &= \sigma_{y_{21}}(\beta, \rho; \delta_{21}(\delta_v, u^2\rho)) \\ \sigma_{y_{22}} &= \sigma_{y_{22}}(\beta, \rho; \delta_{22}(\delta_v, u^2\rho)) \end{aligned} \tag{6.37}$$

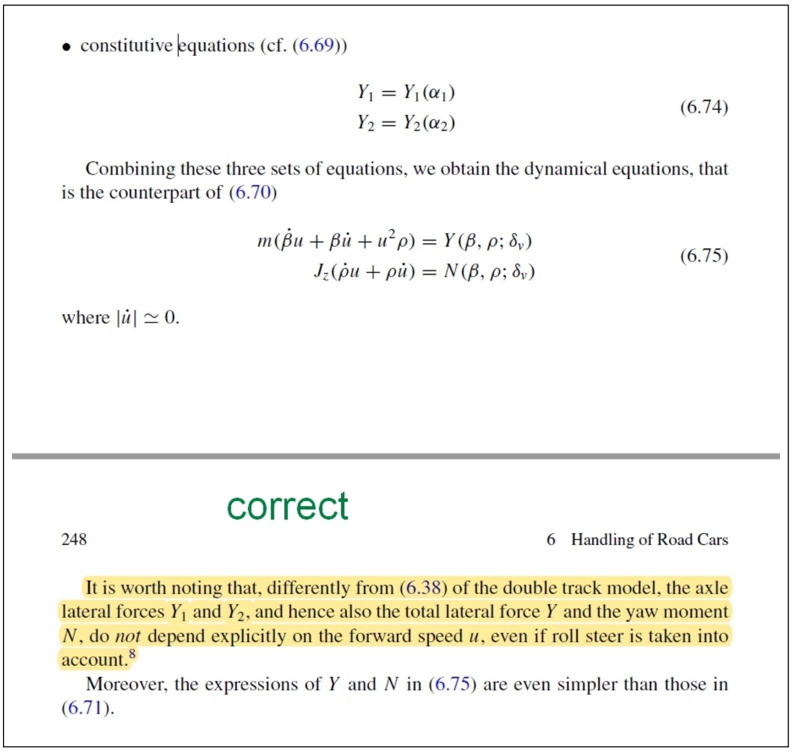
Therefore, in this case, the two dynamical equations (6.34) of the double track model become

$$\begin{aligned} m(\dot{\beta}u + \beta\dot{u} + u^2\rho) &= Y(\beta, \rho; \delta_v, u^2\rho) \\ J_z(\dot{\rho}u + \rho\dot{u}) &= N(\beta, \rho; \delta_v, u^2\rho) \end{aligned} \tag{6.38}$$

where $|\dot{u}| \simeq 0$ and can be discarded. The dependence of Y and N on the lateral acceleration $u^2\rho$, and hence on the forward speed u, disappears if there is no roll steer. This is the main advantage in using β and ρ as state variables in the double track model.

Quite remarkably, we will see in (6.75) that in the single track model there is no dependence of Y and N on u when β and ρ are used as state variables, even if roll steer is taken into account.

Figure 1: Wrong sentence



- constitutive equations (cf. (6.69))

$$
\begin{aligned}
Y_1 &= Y_1(\alpha_1)\\
Y_2 &= Y_2(\alpha_2)
\end{aligned}
\qquad (6.74)
$$

Combining these three sets of equations, we obtain the dynamical equations, that is the counterpart of (6.70)

$$
\begin{aligned}
m(\dot{\beta}u + \beta\dot{u} + u^2\rho) &= Y(\beta, \rho; \delta_v)\\
J_z(\dot{\rho}u + \rho\dot{u}) &= N(\beta, \rho; \delta_v)
\end{aligned}
\qquad (6.75)
$$

where $|\dot{u}| \simeq 0$.

correct

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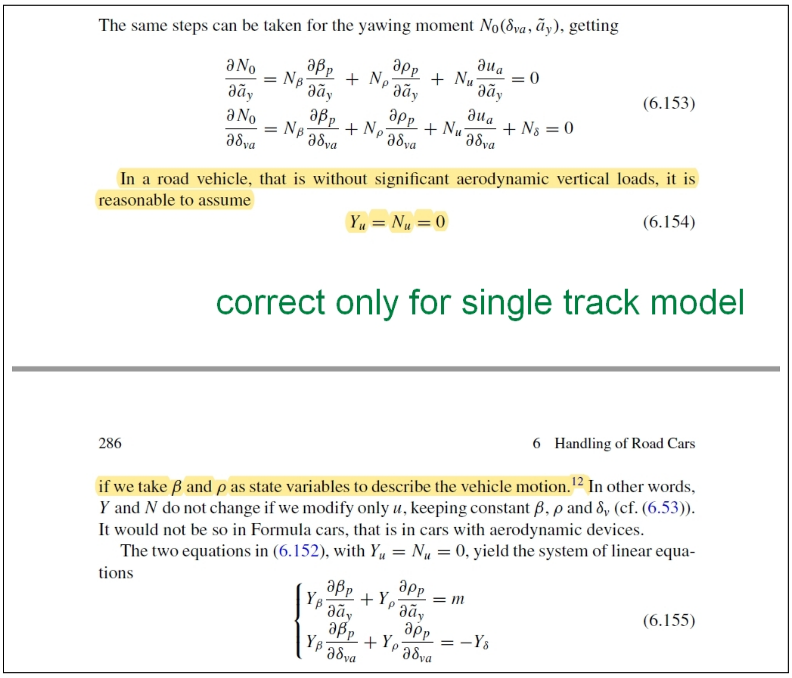
It is worth noting that, differently from (6.38) of the double track model, the axle lateral forces Y_1 and Y_2, and hence also the total lateral force Y and the yaw moment N, do *not* depend explicitly on the forward speed u, even if roll steer is taken into account.[8]

Moreover, the expressions of Y and N in (6.75) are even simpler than those in (6.71).

Figure 2: Correct sentence



The same steps can be taken for the yawing moment $N_0(\delta_{va}, \tilde{a}_y)$, getting

$$
\begin{aligned}
\frac{\partial N_0}{\partial \tilde{a}_y} &= N_\beta \frac{\partial \beta_p}{\partial \tilde{a}_y} + N_\rho \frac{\partial \rho_p}{\partial \tilde{a}_y} + N_u \frac{\partial u_a}{\partial \tilde{a}_y} = 0\\
\frac{\partial N_0}{\partial \delta_{va}} &= N_\beta \frac{\partial \beta_p}{\partial \delta_{va}} + N_\rho \frac{\partial \rho_p}{\partial \delta_{va}} + N_u \frac{\partial u_a}{\partial \delta_{va}} + N_\delta = 0
\end{aligned}
\qquad (6.153)
$$

In a road vehicle, that is without significant aerodynamic vertical loads, it is reasonable to assume

$$
Y_u = N_u = 0 \qquad (6.154)
$$

correct only for single track model

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if we take β and ρ as state variables to describe the vehicle motion.[12] In other words, Y and N do not change if we modify only u, keeping constant β, ρ and δ_v (cf. (6.53)). It would not be so in Formula cars, that is in cars with aerodynamic devices.

The two equations in (6.152), with $Y_u = N_u = 0$, yield the system of linear equations

$$
\begin{cases}
Y_\beta \dfrac{\partial \beta_p}{\partial \tilde{a}_y} + Y_\rho \dfrac{\partial \rho_p}{\partial \tilde{a}_y} = m\\
Y_\beta \dfrac{\partial \beta_p}{\partial \delta_{va}} + Y_\rho \dfrac{\partial \rho_p}{\partial \delta_{va}} = -Y_\delta
\end{cases}
\qquad (6.155)
$$

Figure 3: Sentence needing additional comments

[First reported by *Danilo Biggio and Massimo Guiggiani* on 20 September 2020]

Ch. 6, page 254, line −2

Replace the text of the footnote with: Strictly speaking, equation (6.49) should also be fulfilled.
[First reported by *Danilo Biggio* on 23 September 2020]

Ch. 6, page 276, line 13 - ADDENDUM

Insert the following text and figure:

Figure 5 exemplifies this paradoxical situation. Three different curves, three identical trajectories, only one is fine in each case. What about the understeer/oversteer behavior of the car? What did the driver intend to do?

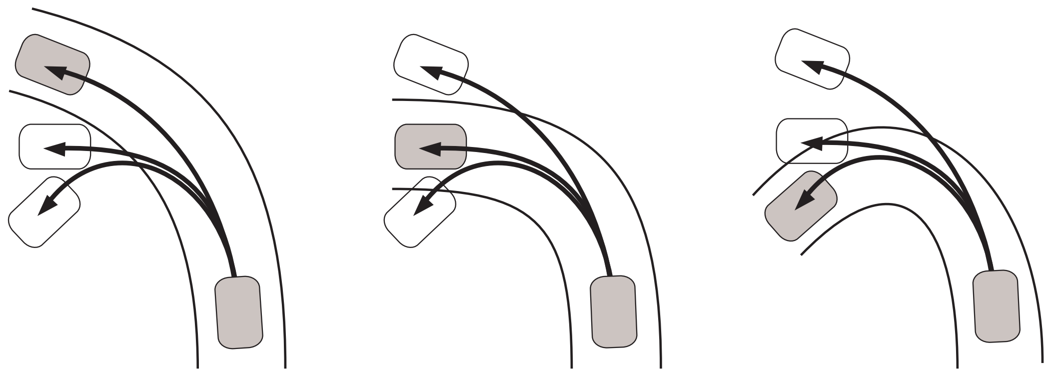

Figure 4: What did the driver intend to do?

[First reported by *Basilio Lenzo* on 22 April 2020]

Ch. 6, page 277, line 4

Replace e with and.
Same correction just after equations (6.128), (6.190), (6.210), (6.213) and (6.231).
[First reported by *Shaid Farzand* on 20 November 2018]

Ch. 6, page 296, line -1

Replace 30 m/s with 20 m/s.
[First reported by *Stylianos (Stelios) Markolefas* on 2 August 2018]

Ch. 6, page 304, line 5

Delete "increasing".
[First reported by *Basilio Lenzo* on 8 April 2020]

Ch. 6, page 307, eq. (6.231)

Replace J with J_z.
Same correction in eq. (6.236).
[First reported by *Shaid Farzand* on 20 November 2018]

Ch. 6, page 317, eq. (6.252)

The correct equation is as follows:

$$\beta_t = \frac{-a_{22}\rho_t + \dot{\rho}_t}{a_{21}}$$

$$\dot{\beta}_t = \frac{(a_{12}a_{21} - a_{11}a_{22})\rho_t + a_{11}\dot{\rho}_t}{a_{21}}$$

[First reported by *Massimo Guiggiani* on 15 November 2018]

Chapter 7 - Handling of Race Cars

Ch. 7, page 338, line 12

It should be $Y_2(\alpha_2, u)$.
[First reported by *Daniele Duranti* on 30 December 2019]

Ch. 7, page 353, line 6

It should be $\delta - l/R$.
[First reported by *Daniele Duranti* on 30 December 2019]

Ch. 7, page 363, lines 14 and 15

Invert lateral and longitudinal.
[First reported by *Shaid Farzand* on 20 November 2018]

Ch. 7, page 369, line 3

Replace km/h^3 with kg/m^3.
[First reported by *Shaid Farzand* on 20 November 2018]

Ch. 7, page 371, line 15

Delete "for".
[First reported by *Sandro Yemi Okutuga* on 28 November 2019]

Chapter 8 - Map of Achievable Performance (MAP)

Ch. 8, page 377, line 4

"achievable region" is written twice.
[First reported by *Shaid Farzand* on 11 January 2019]

Chapter 9 - Handling with Roll Motion

Ch. 9, page 403, line -3

"Vehicle invariant point" is doubled.
[First reported by *Shaid Farzand* on 11 January 2019]

Ch. 9, page 404, line -6

"Vehicle invariant point" is doubled.
[First reported by *Shaid Farzand* on 11 January 2019]

Ch. 9, page 408, eqn. (9.37)

Delete this equation.
[First reported by *Basilio Lenzo* on 27 July 2022]

Ch. 9, page 408, eq. (9.38)

m is missing on the r.h.s.
[First reported by *Shaid Farzand* on 11 January 2019]

Chapter 10 - Ride Comfort and Road Holding

Ch. 10, page 425, eq. (10.22)

Replace $+pk$ with $+p(k - b\Omega^2)$.
[First reported by *Massimo Guiggiani* on 18 December 2018]

Ch. 10, page 432, Fig. 10.9

Ω is in Hz.
[First reported by *Massimo Guiggiani* on 18 December 2018]

Ch. 10, page 434, Fig. 10.12

Ω is in Hz.
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Ch. 10, page 435, Fig. 10.13

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[First reported by *Massimo Guiggiani* on 18 December 2018]

Ch. 10, page 439, line −17

Replace "vehicle dynamic" with "vehicle dynamics".
[First reported by *Basilio Lenzo* on 12 February 2019]

Ch. 10, page 443, line 3

Replace "further this topic" with "this topic further".
[First reported by *Basilio Lenzo* on 12 February 2019]

Ch. 10, page 448, line −12

Replace "discus" with "discuss".
[First reported by *Basilio Lenzo* on 12 February 2019]

Chapter 11 - Tire Models

Ch. 11, page 482, eq. (11.66)

The correct equation is

$$k\mathbf{e}_f = -\mu_1 p \frac{\boldsymbol{\lambda} - \mathbf{e}'_f}{|\boldsymbol{\lambda}|}$$
$$k\tilde{\mathbf{e}}_s = -\mu_1 p \frac{\mathbf{e}_f}{|\mathbf{e}_f|}$$

[First reported by *Massimo Guiggiani* on 13 October 2021]

Ch. 11, page 490, eq. (11.83)

The correct equation is

$$t_c = \frac{\sigma_y a + \varphi b^2}{3\sigma_y - \varphi a}$$

[First reported by *Shaid Farzand* on 19 January 2019]

Ch. 11, page 490, eq. (11.85)

The correct equation is

$$t_c = -\frac{b^2}{a}$$

[First reported by *Shaid Farzand* on 19 January 2019]

Ch. 11, eqs. 11.90, (11.91) and (11.101)

Replace κ with k.
[First reported by *Shaid Farzand* on 19 January 2019]

Ch. 11, page 519, line −6

Replace ¡8 with (.
[First reported by *Shaid Farzand* on 19 January 2019]

Ch. 11, page 533, line −3

Replace ”the” with ”there”.
[First reported by *Cesare Certosini* on 12 February 2019]

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Ch. 10, page 439, line -17

Replace "vehicle dynamic" with "vehicle dynamics".
[First reported by *Basilio Lenzo* on 12 February 2019]

Ch. 10, page 443, line 3

Replace "further this topic" with "this topic further".
[First reported by *Basilio Lenzo* on 12 February 2019]

Ch. 10, page 448, line -12

Replace "discus" with "discuss".
[First reported by *Basilio Lenzo* on 12 February 2019]

Errata and addenda also for the corrected printing

Ch. 5, page 204, eqn. (5.25)**, second line**

Should be $-\dot{S}$.
[First reported by *Eleonora D'Ortenzi and Marta Bartalesi* on 5 April 2019]

Ch. 3, page 102, line -7

Replace < 0 with > 0.
[First reported by *Andrea Quintarelli* on 30 June 2019]

Ch. 5, page 196, line -1

Replace $\hat{be}_1$ with $\hat{\beta}_1$.
[First reported by *Daniele Duranti* on 26 July 2019]

Ch. 5, page 210, line 10

"Evolute" is doubled.
[First reported by *Daniele Duranti* on 26 July 2019]

Ch. 5, page 211, line 1

Replace rad/s^2 with rad/s.
[First reported by *Daniele Duranti* on 26 July 2019]

Ch. 2, page 23, last line

"trailing rolling" should be "tractive rolling"
[First reported by *Stylianos (Stelios) Markolefas* on 4 September 2019]

Ch. 6, page 215, line 14

(3.85) should be (3.84)
[First reported by *Stylianos (Stelios) Markolefas* on 4 September 2019]

Ch. 4, page 180, eqn. (4.30)

Flip the sign of the term on the r.h.s., thus obtaining

$$u(t) = u_d \tan\left(\arctan\left(\frac{u_0}{u_d}\right) - \frac{t}{t_d}\right)$$

[First reported by *Tommaso Bugliesi* on 1 October 2019]

Ch. 4, page 185, line -13

300/3.6 is equal to 83.33
[First reported by *Daniele Duranti* on 1 October 2019]

Ch. 2, page 14, eqn. (2.7)

The correct equation is as follows

$$\begin{aligned}\mathbf{V}_o &= V_{o_x}\mathbf{i} + V_{o_y}\mathbf{j}\\ &= V_{o_x}(\mathbf{i} - \tan\alpha\mathbf{j})\end{aligned}$$

[First reported by *Emanuele Di Pino* on 10 October 2019]

Ch. 2, page 16, line 1

Insert ($d_t < 0$) at the end of the caption.
[First reported by *Massimo Guiggiani* on 25 October 2019]

Ch. 7, page 371, line 15

Delete "for".
[First reported by *Sandro Yemi Okutuga* on 28 November 2019]

Ch. 7, page 338, line 12

It should be $Y_2(\alpha_2, u)$.
[First reported by *Daniele Duranti* on 30 December 2019]

Ch. 7, page 353, line 6

It should be $\delta - l/R$.
[First reported by *Daniele Duranti* on 30 December 2019]

2020

Ch. 6, page 304, line 5

Delete ”increasing”.
[First reported by *Basilio Lenzo* on 8 April 2020]

Ch. 6, page 276, line 13 - ADDENDUM

Insert the following text and figure:

Figure 5 exemplifies this paradoxical situation. Three different curves, three identical trajectories, only one is fine in each case. What about the understeer/oversteer behavior of the car? What did the driver intend to do?

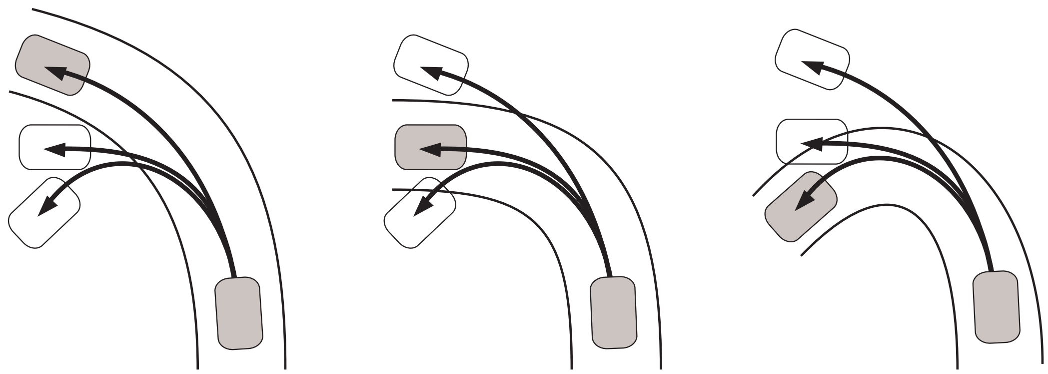


Figure 5: What did the driver intend to do?

[First reported by *Basilio Lenzo* on 22 April 2020]

Ch. 4, page 181 - ADDENDUM

Optimal practical brake balance for Formula cars

As commonly done by race engineers, in addition to the brake balance $\beta = X1/X2$, we define the *practical brake balance* η

$$\eta = \frac{X_1}{X_1 + X_2}$$

along with the *weight distribution* ω

$$\omega = \frac{Z_1^0}{Z_1^0 + Z_2^0} = \frac{a_2}{a_1 + a_2}$$

and the *aero balance* α

$$\alpha = \frac{C_{z_1}}{C_{z_1} + C_{z_2}} = \frac{\zeta_1}{\zeta_1 + \zeta_2} = \frac{\zeta_1}{\zeta}$$

where $\zeta = \zeta_1 + \zeta_2$.

We obtain the following result for the *optimal* practical brake balance η_p

$$\eta_p = \frac{mg(\mu\frac{h}{l} + \omega) + \zeta u^2(\mu\frac{h}{l} + \alpha) + \xi u^2 \frac{h}{l}}{mg + \zeta u^2}$$

which is the counterpart of (4.35). Of course, in general, η_p is speed dependent.

To avoid speed dependence of η_p (like in Fig. 4.11), it must be $\partial\eta_p/\partial u = 0$, that means

$$(\omega - \alpha)\zeta - \frac{h}{l}\xi = 0$$

or, equivalently

$$(\omega - \alpha)C_z - \frac{h}{l}C_x = 0$$

which can be rewritten as

$$\omega = \alpha + \frac{C_x}{C_z}\frac{h}{l}$$

These last three equations are the counterpart of (4.37). We see that, to avoid speed dependence of η_p, it is necessary that $\omega > \alpha$, but just a little. For instance, in a Formula car, it results $\omega - \alpha \simeq 0.02$.

Sensitivity of the optimal practical brake balance η_p with respect to aero balance α

$$\frac{\partial\eta_p}{\partial\alpha} = \frac{\zeta u^2}{mg + \zeta u^2}$$

Very simple formula. No μ, no h/l, no C_x. Strong speed dependence at high speed.

Sensitivity of the optimal practical brake balance η_p with respect to weight distribution ω

$$\frac{\partial\eta_p}{\partial\omega} = \frac{mg}{mg + \zeta u^2}$$

Very simple formula. No μ, no h/l, no C_x. Strong speed dependence at low speed.
[First reported by *Massimo Guiggiani* with *Ernesto Desiderio* on 6 May 2020]

Ch. 3, page 87, line 1

Add "and $\delta_1^0 = 0$" inside the parentheses.
[First reported by *Massimo Guiggiani* on 13 May 2020]

Ch. 4, page 173, eqn. (4.15) - ADDENDUM

Optimal brake balance with front to rear different grip (no aero loads)

Let μ_1 be the coefficient of friction of the front axle, and μ_2 be the coefficient of friction of the rear axle.

Then, the optimal brake balance β_P is given by

$$\beta_P = \frac{X_{1_P}}{X_{2_P}} = \frac{\mu_1(a_2 + h\mu_2)}{\mu_2(a_1 - h\mu_1)}$$

that generalizes (4.15)
[First reported by *Massimo Guiggiani* on 22 June 2020]

Ch. 4, page 181 - ADDENDUM

Optimal practical brake balance for Formula cars with front to rear different grip

Let μ_1 be the coefficient of friction of the front axle, and μ_2 be the coefficient of friction of the rear axle.

Then, the optimal practical brake balance η_p is given by

$$\eta_p = \frac{X_{1_P}}{X_{1_P}+X_{2_P}} = \frac{\mu_1\left[mg(\mu_2\frac{h}{l}+\omega)+\zeta u^2(\mu_2\frac{h}{l}+\alpha)+\xi u^2\frac{h}{l}\right]}{mg[\mu_1\omega+\mu_2(1-\omega)]+\zeta u^2[\mu_1\alpha+\mu_2(1-\alpha)]+\xi u^2\frac{h}{l}(\mu_1-\mu_2)}$$

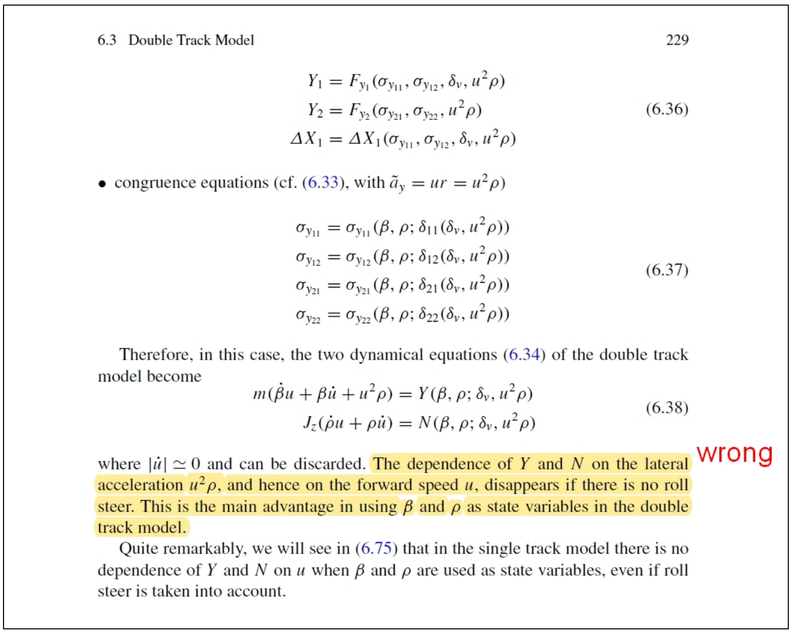
[First reported by *Massimo Guiggiani* with *Federico Sánchez Motellón* on 22 June 2020]

Ch. 5, page 197, line 16

Replace centerthe with center, but only in the pdf edition!
[First reported by *Simone Vollaro* on 11 August 2020]

Ch. 6, pages 229, 248, 286

IMPORTANT
In these pages there are some errors, as explained hereafter:



6.3 Double Track Model 229

$$\begin{aligned} Y_1 &= F_{y_1}(\sigma_{y_{11}}, \sigma_{y_{12}}, \delta_v, u^2\rho) \\ Y_2 &= F_{y_2}(\sigma_{y_{21}}, \sigma_{y_{22}}, u^2\rho) \\ \Delta X_1 &= \Delta X_1(\sigma_{y_{11}}, \sigma_{y_{12}}, \delta_v, u^2\rho) \end{aligned} \qquad (6.36)$$

- congruence equations (cf. (6.33), with $\tilde{a}_y = ur = u^2\rho$)

$$\begin{aligned} \sigma_{y_{11}} &= \sigma_{y_{11}}(\beta, \rho; \delta_{11}(\delta_v, u^2\rho)) \\ \sigma_{y_{12}} &= \sigma_{y_{12}}(\beta, \rho; \delta_{12}(\delta_v, u^2\rho)) \\ \sigma_{y_{21}} &= \sigma_{y_{21}}(\beta, \rho; \delta_{21}(\delta_v, u^2\rho)) \\ \sigma_{y_{22}} &= \sigma_{y_{22}}(\beta, \rho; \delta_{22}(\delta_v, u^2\rho)) \end{aligned} \qquad (6.37)$$

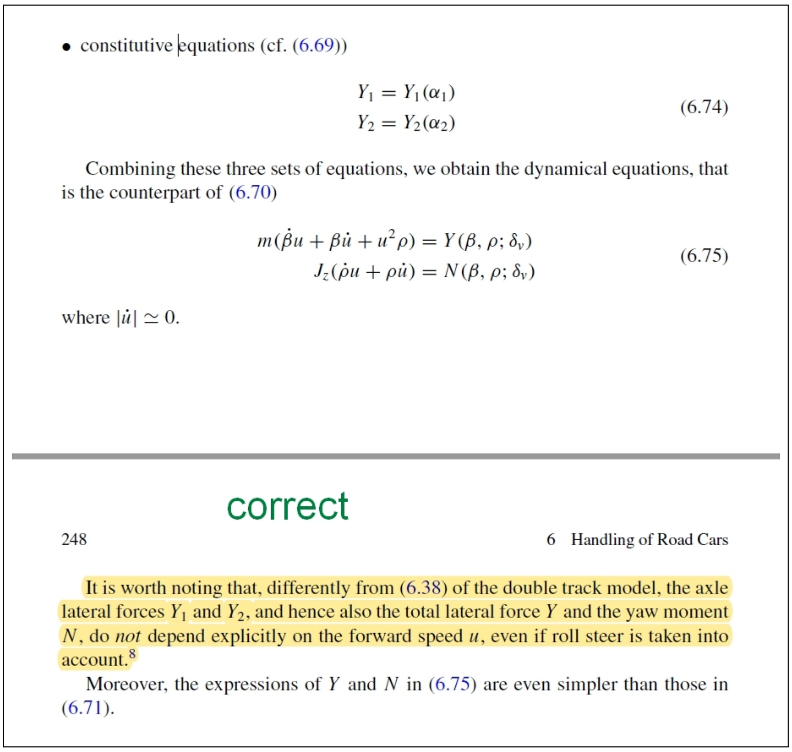
Therefore, in this case, the two dynamical equations (6.34) of the double track model become

$$\begin{aligned} m(\dot\beta u + \beta\dot u + u^2\rho) &= Y(\beta, \rho; \delta_v, u^2\rho) \\ J_z(\dot\rho u + \rho\dot u) &= N(\beta, \rho; \delta_v, u^2\rho) \end{aligned} \qquad (6.38)$$

where $|\dot u| \simeq 0$ and can be discarded. The dependence of Y and N on the lateral acceleration $u^2\rho$, and hence on the forward speed u, disappears if there is no roll steer. This is the main advantage in using β and ρ as state variables in the double track model.

Quite remarkably, we will see in (6.75) that in the single track model there is no dependence of Y and N on u when β and ρ are used as state variables, even if roll steer is taken into account.

Figure 6: Wrong sentence



- constitutive equations (cf. (6.69))

$$\begin{aligned} Y_1 &= Y_1(\alpha_1) \\ Y_2 &= Y_2(\alpha_2) \end{aligned} \tag{6.74}$$

Combining these three sets of equations, we obtain the dynamical equations, that is the counterpart of (6.70)

$$\begin{aligned} m(\dot{\beta}u + \beta\dot{u} + u^2\rho) &= Y(\beta, \rho; \delta_v) \\ J_z(\dot{\rho}u + \rho\dot{u}) &= N(\beta, \rho; \delta_v) \end{aligned} \tag{6.75}$$

where $|\dot{u}| \simeq 0$.

correct

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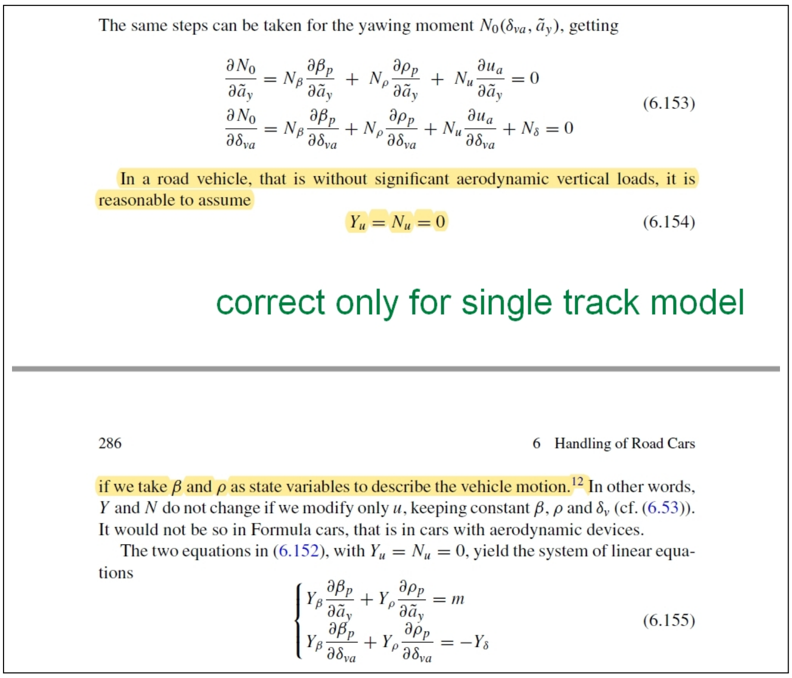
It is worth noting that, differently from (6.38) of the double track model, the axle lateral forces Y_1 and Y_2, and hence also the total lateral force Y and the yaw moment N, do *not* depend explicitly on the forward speed u, even if roll steer is taken into account.[8]

Moreover, the expressions of Y and N in (6.75) are even simpler than those in (6.71).

Figure 7: Correct sentence



The same steps can be taken for the yawing moment $N_0(\delta_{va}, \tilde{a}_y)$, getting

$$\begin{aligned} \frac{\partial N_0}{\partial \tilde{a}_y} &= N_\beta \frac{\partial \beta_p}{\partial \tilde{a}_y} + N_\rho \frac{\partial \rho_p}{\partial \tilde{a}_y} + N_u \frac{\partial u_a}{\partial \tilde{a}_y} = 0 \\ \frac{\partial N_0}{\partial \delta_{va}} &= N_\beta \frac{\partial \beta_p}{\partial \delta_{va}} + N_\rho \frac{\partial \rho_p}{\partial \delta_{va}} + N_u \frac{\partial u_a}{\partial \delta_{va}} + N_\delta = 0 \end{aligned} \tag{6.153}$$

In a road vehicle, that is without significant aerodynamic vertical loads, it is reasonable to assume

$$Y_u = N_u = 0 \tag{6.154}$$

correct only for single track model

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if we take β and ρ as state variables to describe the vehicle motion.[12] In other words, Y and N do not change if we modify only u, keeping constant β, ρ and δ_v (cf. (6.53)). It would not be so in Formula cars, that is in cars with aerodynamic devices.

The two equations in (6.152), with $Y_u = N_u = 0$, yield the system of linear equations

$$\begin{cases} Y_\beta \dfrac{\partial \beta_p}{\partial \tilde{a}_y} + Y_\rho \dfrac{\partial \rho_p}{\partial \tilde{a}_y} = m \\ Y_\beta \dfrac{\partial \beta_p}{\partial \delta_{va}} + Y_\rho \dfrac{\partial \rho_p}{\partial \delta_{va}} = -Y_\delta \end{cases} \tag{6.155}$$

Figure 8: Sentence needing additional comments

[First reported by *Danilo Biggio and Massimo Guiggiani* on 20 September 2020]

Ch. 6, page 254, line −2

Replace the text of the footnote with: Strictly speaking, equation (6.49) should also be fulfilled. [First reported by *Danilo Biggio* on 23 September 2020]

2021

Ch. 3, page 138, eqn. (3.186)

The correct form is

$$\zeta = \frac{\arctan(\chi \Delta\hat{\omega}\, \mathrm{sign}(M_h))}{\pi/2}$$

[First reported by *Lorenzo Bartali* on 25 June 2021]

2022

Ch. 9, page 408, eqn. (9.37)

Delete this equation.
[First reported by *Basilio Lenzo* on 27 July 2022]