

OPTIMUMG OPTIMUM TIRE - FORMULA STUDENT

Wheel configuration choice for the vehicle Invictus (2020 season)

Direction and management

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Suspension system

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1 Introduction

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2 Stakeholder analysis

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3 Wheel requirements specification

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4 Concept generation

| Tx | | Ту | p | skidpad mean radius | smallest en | durance me | an radius | usd2€ | 0,9 | |
|---|---|---|--|--|--|---|---|--|--|-----------|
| mm | | mm | mm | m | m | | | in2mm | 25,4 | |
| 1650 | | 1250 | 1035 | 9 | 3 | | | lbs2g | 453,592 | |
| tyre | | model | outer radiu | width | mass | Iy | Iz | price | TTC | data |
| code | | str | mm | mm | g | kg m^2 | kg m^2 | € HT sans sped. | | drive/bra |
| 1 | | Hoosier 20,5/7 - 13 | 260 | 178 | 4990 | 60 | - | 205 | | y |
| 2 | | Hoosier 16/7.5 -10 | 203 | 191 | 3402 | 27 | 13 | 180 | - | n |
| 3 | | Hoosier 18/7.5 - 10 | 229 | 191 | 4536 | 45 | 23 | 180 | - | у |
| 4 | | C19 205/470 r13 | 235 | 205 | 3924 | 44 | | 183 | - | |
| 5 | | Avon 16/7-10 | 203 | 178 | 3266 | 24 | | 104 | | y n |
| | | | | | | | | | | |
| rim | | model | radius | width | mass | Iy | Iz | price | notes | |
| code | | str | mm | mm | g | kg m^2 | kg m^2 | € HT sans sped. | | |
| a | | OZ 13 Mg | 165 | 178 | 2450 | 12 | 6 | 250 | not center | lock |
| b | | OZ 10 Mg | 127 | 178 | 1660 | 5 | 2 | 250 | center lock | |
| c | | keizer 10i Al | 127 | 178 | 2041 | 6 | 3 | 248 | \$265 8 piec | ces |
| d | | keizer 13 Al | 165 | 178 | 2835 | 14 | 7 | 338 | | |
| | | | | | | | | | | |
| e | | Oz 13 Al | 165 | 178 | 3400 | 16 | 8 | 260 | sa coute au | moins co |
| e | | | | | 3400 | 16 | 8 | 260 | sa coute au | moins co |
| | yy/r^2> wl | Oz 13 Al | | | 3400 | 16 | 8 | 260 | sa coute au | moins co |
| a = m +Iy b = m+Iz | _G/R^2> | heel contribution to the | e y-rotation skidpad z-ro | energy otation energy | | 16 | 8 | 260 | sa coute au | moins co |
| a = m +Iy b = m+Iz | _G/R^2> | heel contribution to the | e y-rotation skidpad z-ro | energy otation energy | | 16 | 8 | 260 | sa coute au | moins co |
| a = m + Iy $b = m + Iz$ $c = m + Iz$ | _G/R^2> | heel contribution to the | e y-rotation skidpad z-ro | energy otation energy | у | | 8 | 260 | sa coute au | moins co |
| a = m + Iy $b = m + Iz$ $c = m + Iz$ | _G/R^2> | heel contribution to the wheel contribution to seed to the contribution to seed to the contribution to seed to the contribution to seed to the contribution to the | e y-rotation skidpad z-ro n to smalles | energy otation energy | y Iz_G | price | a | 260 b | sa coute au | moins co |
| a = m +Iy b = m+Iz c = m+Iz config | z_G/R^2> z_G/R_min^2 | heel contribution to the wheel contribution to seed to the contribution to seed to the contribution to seed to the contribution to seed to the contribution to the | e y-rotation skidpad z-ro n to smalles | energy station energy st turn z-rotation energ | у | | a | | | moins co |
| a = m +Iy b = m+Iz c = m+Iz config rim tyre a1* | g_G/R^2> g_G/R_min^2 outer radius m | heel contribution to the wheel contribution to so 2> wheel contribution to so mass | e y-rotation skidpad z-ro n to smalles | energy otation energy st turn z-rotation energ Izz kg m^2 | y Iz_G | price | a param 8502 | b | c | moins co |
| a = m +Iy b = m+Iz c = m+Iz config rim tyre a1* | G/R^2> G/R_min^2 outer radius m 0,260 0,235 | heel contribution to the wheel contribution to seed to the contribution to seed to the contribution seed to the contribut | e y-rotation skidpad z-ro in to smalles Iyy kg m^2 | energy station energy st turn z-rotation energ Izz kg m^2 36 28 | Iz_G kg m^2 44 35 | price € HT sans 205 183 | a: param 8502 7393 | b param 7440 6374 | c param 7444 6377 | moins co |
| a = m +Iy b = m+Iz c = m+Iz config rim tyre a1* | g_G/R^2> g_G/R_min^2 outer radius m | heel contribution to the wheel contribution to \$2> wheel contribution to \$4 mass \$4 | e y-rotation skidpad z-ro in to smalles Iyy kg m^2 | energy otation energy st turn z-rotation energ Izz kg m^2 | Iz_G kg m^2 | price € HT sans 205 | a sparam 8502 7393 8914 | b param 7440 | c param 7444 | moins co |
| a = m +Iy b = m+Iz c = m+Iz config rim tyre a1* a4 * | G/R^2> G/R_min^2 outer radius m 0,260 0,235 0,260 0,165 | heel contribution to the wheel contribution to seed to the contribution to seed to the contribution seed to the contribut | lyy kg m^2 | energy station energy st turn z-rotation energ Izz kg m^2 36 28 | Iz_G kg m^2 44 35 45 36 | price € HT sans 205 183 543 521 | a sparam 8502 7393 8914 8892 | b param 7440 6374 7825 6759 | c param 7444 6377 7829 6762 | moins co |
| a = m +Iy b = m+Iz | outer radius m 0,260 0,235 0,260 0,165 0,203 | heel contribution to the wheel contribution to seed to the wheel contribution to seed to see the wheel contribution to see the wheel con | lyy kg m^2 | lzz kg m^2 36 28 37 29 | Iz_G kg m^2 44 35 45 36 21 | price € HT sans 205 183 543 | a sparam 8502 7393 8914 8892 | b param 7440 6374 7825 | c param 7444 6377 7829 6762 5064 | moins co |
| a = m +Iy b = m+Iz c = m+Iz config rim tyre a1* a4 * d1 d4 b2 b3 | outer radius m 0,260 0,235 0,260 0,165 0,203 0,229 | heel contribution to the wheel contribution to see 2> wheel contribution to see a smasse ger a see | lyy kg m^2 72 56 74 58 32 50 | lzz kg m^2 36 28 37 29 16 25 | y Iz_G kg m^2 44 35 45 36 21 32 | price € HT sans 205 183 543 521 430 | a 8502 7393 8914 8892 5825 7151 | b param 7440 6374 7825 6759 5062 6196 | c param 7444 6377 7829 6762 5064 6199 | moins co |
| a = m +Iy b = m+Iz c = m+Iz config rim tyre a1* a4 * d1 d4 b2 b3 | outer radius m 0,260 0,235 0,260 0,165 0,203 | heel contribution to the wheel contribution to seed to the contribution to the wheel contribution to the contribution to seed | lyy kg m^2 72 56 74 58 32 50 | lzz kg m^2 36 28 37 29 | Iz_G kg m^2 44 35 45 36 21 32 20 | price € HT sans 205 183 543 521 430 | a *param 8502 7393 8914 8892 5825 7151 5622 | b param 7440 6374 7825 6759 5062 6196 4926 | c param 7444 6377 7829 6762 5064 6199 4927 | moins co |
| a = m +Iy b = m+Iz c = m+Iz cconfig rrim tyre a1* a4 * d1 d4 b2 b3 | outer radius m 0,260 0,235 0,260 0,165 0,203 0,229 | heel contribution to the wheel contribution to seed to the contribution to the wheel contribution to the contribution to seed to seed to the contribution to seed to s | lyy kg m^2 72 56 74 58 32 50 | lzz kg m^2 36 28 37 29 16 25 | Iz_G kg m^2 44 35 45 36 21 32 | price € HT sans 205 183 543 521 430 | a sparam 8502 7393 8914 8892 5825 7151 5622 | b param 7440 6374 7825 6759 5062 6196 4926 | c param 7444 6377 7829 6762 5064 6199 4927 | moins co |
| a = m +Iy b = m+Iz c = m+Iz c = m+Iz c = m+Iz d = a1* a4 * d1 d4 b2 b3 b5 c2 | outer radius m 0,260 0,235 0,260 0,165 0,203 0,229 0,203 | heel contribution to the wheel contribution to see the contribution to the wheel contribution to the wheel contribution to the wheel contribution to the wheel contribution to see the contribution to | lyy kg m^2 56 74 58 32 50 29 33 | energy station energy st turn z-rotation energe Izz kg m^2 36 28 37 29 16 25 14 | Iz_G kg m^2 44 35 45 36 21 32 20 | price € HT sans 205 183 543 521 430 430 354 428 | a param 8502 7393 8914 8892 5825 7151 5622 6233 | b param 7440 6374 7825 6759 5062 6196 4926 5443 | c param 7444 6377 7829 6762 5064 6199 4927 5445 | moins co |
| a = m +Iy b = m+Iz c = m+Iz c = m+Iz c = m+Iz c = m+Iz d = a1* a4 * d1 d4 b2 b3 b5 c2 c3 | outer radius m 0,260 0,235 0,260 0,165 0,203 0,229 0,203 | heel contribution to the wheel contribution to seed to the contribution to the wheel contribution to seed to the contribution to seed to s | lyy kg m^2 56 74 58 32 50 29 33 | lzz kg m^2 36 28 37 29 16 25 14 16 26 | Iz_G kg m^2 44 35 45 36 21 32 20 | price € HT sans 205 183 543 521 430 430 354 428 | a 8502 7393 8914 8892 5825 7151 5622 6233 7553 | b 7440 6374 7825 6759 5062 6196 4926 5443 | c param 7444 6377 7829 6762 5064 6199 4927 5445 6580 | moins co |
| a = m +Iy b = m+Iz c = m+Iz config rim tyre a1* a4 * d1 d4 | outer radius m 0,260 0,235 0,260 0,165 0,203 0,229 0,203 0,203 | heel contribution to the wheel contribution to seed to the contribution to the wheel contribution to seed to the contribution to seed to s | lyy kg m^2 56 74 58 32 50 29 33 51 | lzz kg m^2 36 28 37 29 16 25 14 16 26 15 | Iz_G kg m^2 44 35 45 36 21 32 20 22 33 | price € HT sans 205 183 543 521 430 430 4304 428 | a 8502 7393 8914 8892 5825 7151 5622 6233 7553 6029 | b param 7440 6374 7825 6759 5062 6196 4926 5443 6577 5307 | c param 7444 6377 7829 6762 5064 6199 4927 5445 6580 5309 | moins co |
| a = m +Iy b = m+Iz c = m+Iy c = m+Iz c = m+Iy c | outer radius m 0,260 0,235 0,260 0,165 0,203 0,229 0,203 0,203 | heel contribution to the wheel contribution to seed to the contribution seed to the contribution seed to the contribution to seed to the contribution to the wheel contribution to the contribution to the wheel contribution to seed to the contribution to seed to s | lyy kg m^2 | lzz kg m^2 36 28 37 29 16 25 14 16 26 15 | Iz_G kg m^2 44 35 45 36 21 32 20 22 33 21 21 | price € HT sans 205 183 543 521 430 430 354 428 428 | a *param 8502 7393 8914 8892 5825 7151 5622 6233 7553 6029 6029 | b 7440 6374 7825 6759 5062 6196 4926 5443 6577 5307 | c param 7444 6377 7829 6762 5064 6199 4927 5445 6580 5309 5309 | moins co |
| a = m +Iy b = m+Iz c = m+Iz c config config rim tyre a1* a4 * d1 d4 b2 b3 b5 c2 c3 c5 | outer radius m 0,260 0,235 0,260 0,165 0,203 0,203 0,203 0,203 0,203 0,203 0,203 | heel contribution to the wheel contribution to see the contribution of | Iyy kg m^2 56 74 58 32 50 29 33 51 30 | renergy station energy st turn z-rotation energy Izz kg m^2 36 28 37 29 16 25 14 16 26 15 | Iz_G kg m^2 44 35 45 36 21 32 20 22 33 21 21 | price € HT sans 205 183 543 521 430 430 354 428 428 351 104 465 | a *param 8502 7393 8914 8892 5825 7151 5622 6233 7553 6029 6029 | b param 7440 6374 7825 6759 5062 6196 4926 5443 6577 5307 8390 | c param 7444 6377 7829 6762 5064 6199 4927 5445 6580 5309 5309 | moins co |

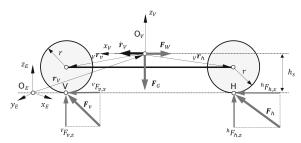
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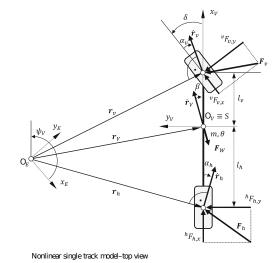


5 Concept selection: a dynamic model

5.1 A nonlinear single track model



Nonlinear single track model—side view



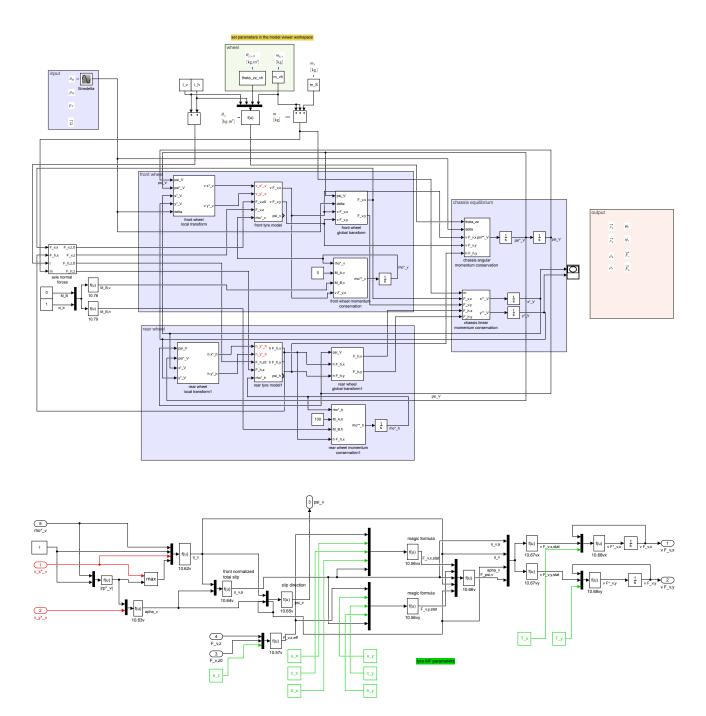
| constant | unit | description | | | | |
|-------------|--------|---|--|--|--|--|
| l_v | m | distance between S and the front axle (vehicle reference frame) | | | | |
| l_h | m | distance between S and the rear axle (vehicle reference frame) | | | | |
| h_S | m | height of S (ground reference frame) | | | | |
| m_vh | kg | wheel mass | | | | |
| m_S | kg | suspended mass | | | | |
| r | m | tyre outer radius | | | | |
| theta_vh | kg.m^2 | tyre rolling inertia | | | | |
| theta_zz_vh | kg.m^2 | tyre z inertia | | | | |
| u_x | | | | | | |
| u_y | | | | | | |
| c_x | | | | | | |
| c_y | | | | | | |
| b_x | | tyre MF model | | | | |
| b_y | | | | | | |
| e_z | | | | | | |
| T_x | | | | | | |
| T_y | | | | | | |
| g | m/s^2 | acceleration of gravity | | | | |

non linear single track model schema from cap 10.3 of [1]

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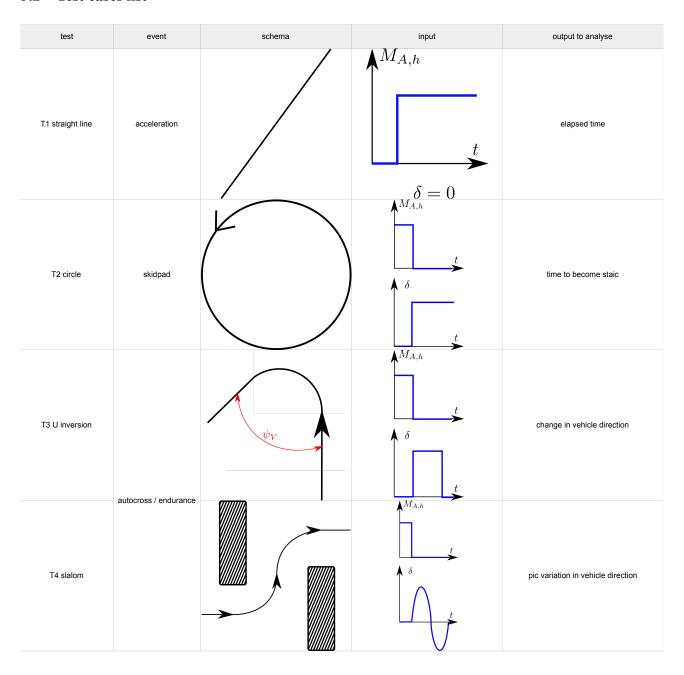
MATLAB Simulink realisation of the non linear model. The Tyre model is expanded in a second view for more detail

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5.2 Test cases list



5.3 Results

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- 6 Conclusion
- **6.1** Wheel configuration choice
- **6.2** Future work

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References

[1] Bardini Schramm, Hiller: Vehicle Dynamics: Modeling and Simulation. 2018, ISBN 9783662544822.

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