

Geometric Weight Transfer and Wheel Load Distribution

Further parts of the weight transfer

Having determined the most significant weight transfer the final, total weight transfer can be found by adding what are usually two less significant weight transfers to the total already found

2. Geometric weight transfer due to sprung mass

3. Geometric weight transfer due to the unsprung mass

2. Geometric weight transfer due to sprung mass WT_{src} taken as acting at the roll centre height and which is resisted by the tyres alone.

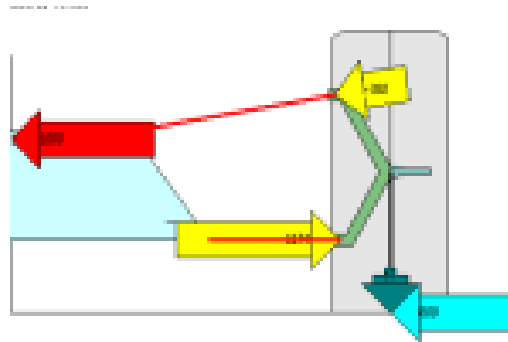
$$WT_{srcf} = \frac{M_{sf} \times a_y \times h_f}{T_f} \quad \text{Eqn 9f}$$

$$WT_{srcr} = \frac{M_{sr} \times a_y \times h_r}{T_r} \quad \text{Eqn 9r}$$

Results for WT_{srcf} and WT_{srcr}

$WT_{srcf} =$

$WT_{srcr} =$



3. Weight transfer due to the unsprung mass - taken as acting at the height of the wheel centre and is resisted by the tyres alone

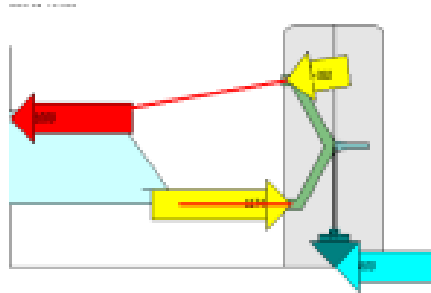
$$WT_{usf} = \frac{M_{usf} \times a_y \times r}{T_f} \quad \text{Eqn 10f}$$

$$WT_{usr} = \frac{M_{usr} \times a_y \times r}{T_r} \quad \text{Eqn 10r}$$

Results for WT_{usf} and WT_{usr}

$WT_{usf} =$

$WT_{usr} =$



Total weight transfer

The total weight transfer is then found from

$$\text{Front} = WT_{sf} + WT_{srcf} + WT_{usf}$$

(Eqn 8f + Eqn 9f + Eqn 10f)

$$\text{Rear} = WT_{sr} + WT_{srcr} + WT_{usr}$$

(Eqn 8r + Eqn 9r + Eqn 10r)

Total weight transfers

Front

Rear

Check value

If the calculations have been carried out accurately the total of the distributed weight transfer found by this method will equal the simple weight transfer found from

$$WT = \frac{M_t a_y H_t}{T}$$

But this will only work if the CG Height is for the combined sprung and unsprung masses

Determination of individual wheel loads

The following suffixes are used to identify the wheel loads .

o = outer i = inner z = vertical y = lateral

So, for example, F_{zof} = Vertical load on the outer front tyre

The front and rear, outer wheel loads can now be determined by taking the static wheel loads and adding the load transfers to them.

Similarly the inner wheel loads can be determined by subtracting the load transfers from their static loads.

Example - Front Outer Wheel Load

$$F_{zof} = (M_{sof} + M_{usof}) \times 9.81 + \text{Total Front Weight Transfer}$$

Final individual corner loads

Corner ←

Front ↑

F_{zif}	F_{zof}
F_{zir}	F_{zor}

Front outer wheel load F_{zof} for example data

The car is turning left so the weight transfer calculated will be added to the static load on the front right wheel due to Unsprung mass (M_{sf}) and the Sprung mass (M_{usf})

$$\begin{aligned}\text{Static load per wheel} &= (M_{sf}/2 + M_{usf}/2) \times 9.81 \\ &= (312/2 + 60/2) \times 9.81 \\ &= (156 + 30) \times 9.81 \\ &= 1824.66 \text{ N}\end{aligned}$$

Front outer wheel load F_{zof}

Total front weight transfer =

Total wheel load

$$F_{zof} = \text{Total front weight transfer} + \text{Static load}$$

Results for individual wheel loads

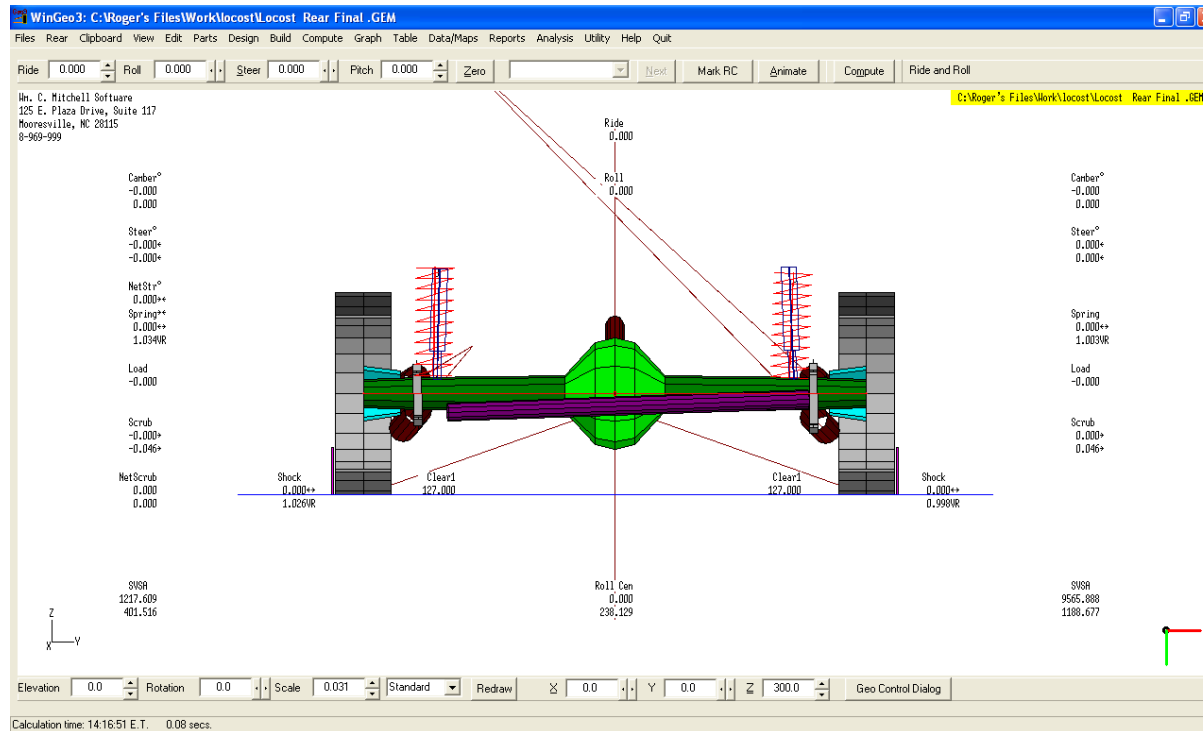
$$F_{zif} =$$

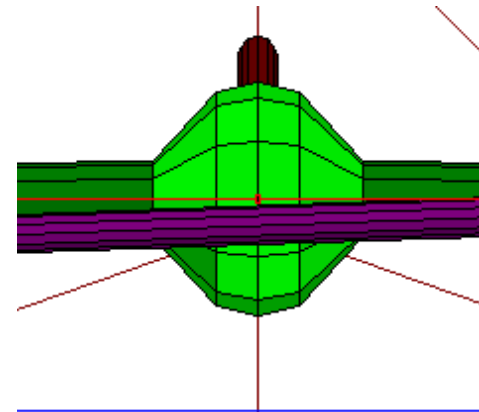
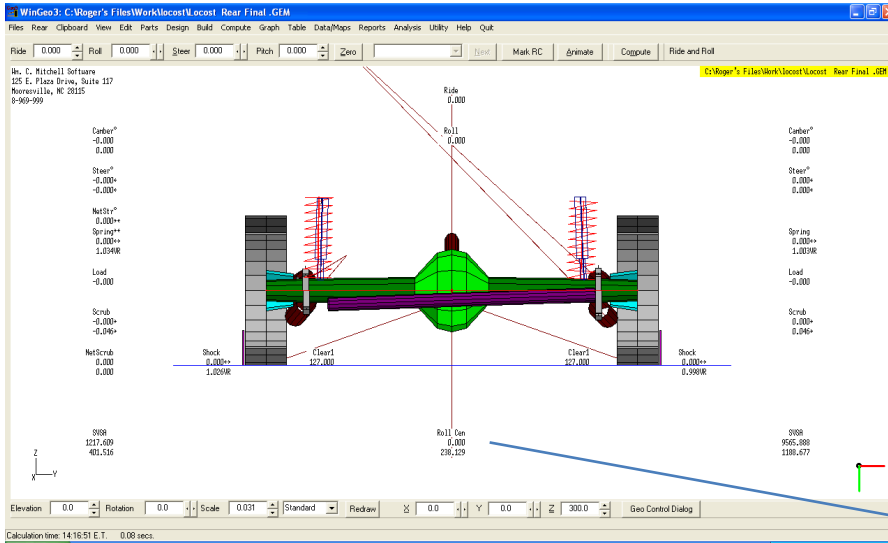
$$F_{zof} =$$

$$F_{zir} =$$

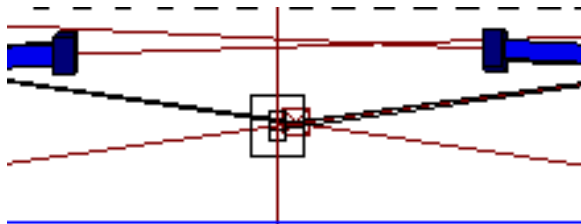
$$F_{zor} =$$

Modifications to calculations needed for a live of deDion type axle

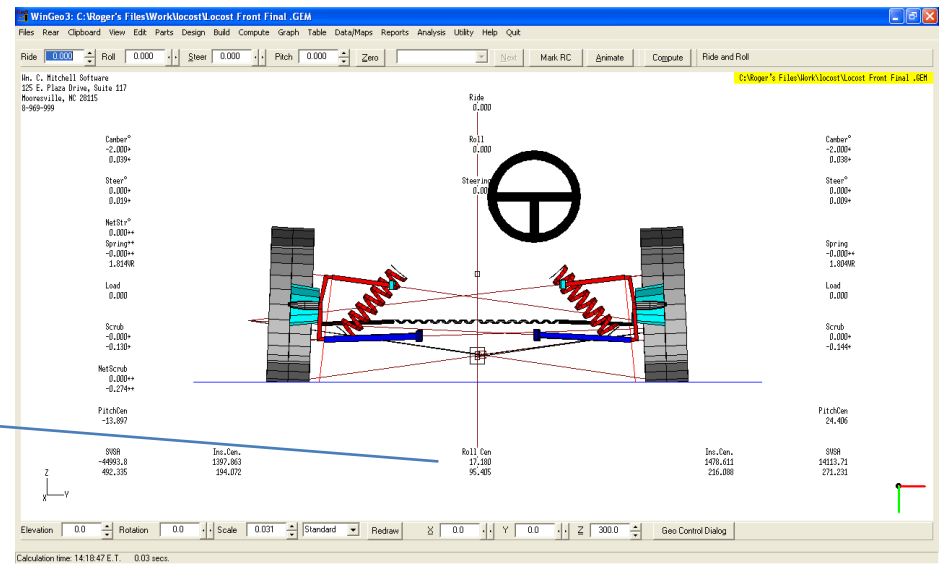




Roll Cen
0.000
230.129

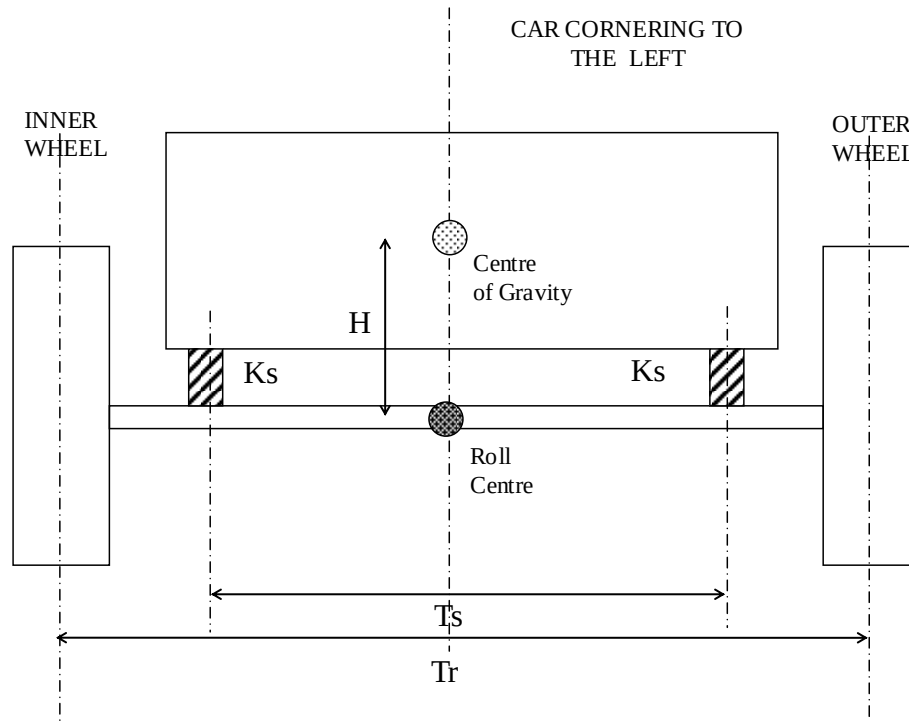


Roll Cen
17.180
95.405



Live axle calculation

Where the vehicle has a rear axle the spring track is used instead of the wheel track and spring rate is used instead of the combined wheel and tyre rate. The body now compresses the springs across the spring track T_s rather than the wheel track.



Roll stiffness for a car with a live axle

The analysis is exactly the same but

Spring track, T_s replaces T_r

K_{wr} is equal to K_{sr} (unless some suspension leverage exists due to the positioning of the Spring)

deflection δ of the wheel is now the direct deflection of the spring on the axle.

$K_{\phi r}$ then becomes

$$K_{\phi r} = \left(\frac{T_s^2}{2} \times K_{wr} \right) \quad \text{Nm/Rad} \quad (\text{Eqn11})$$

Roll angle

The roll angle is now found in the same way as before

$$\varphi = \frac{M_{ot}}{K_{\varphi t}}$$

Weight transfer with live rear axle

With a live rear axle the load increase at the spring is not the weight transfer experienced at the wheel. As the body rolls relative to the axle the outer spring is compressed and the spring load increase is F_{sr} then:

$$F_{sr} = \frac{\varphi T_s K_{sr}}{2}$$

The increased wheel load produced by this increased spring load is WT_{srl}

To find the weight transfer reacted at the wheel,

Equate the moment produced by the increased wheel load WT_{srl} with moment produced by increased spring load F_{sr}

$$WT_{srl} \times T_r = F_{sr} \times T_s$$

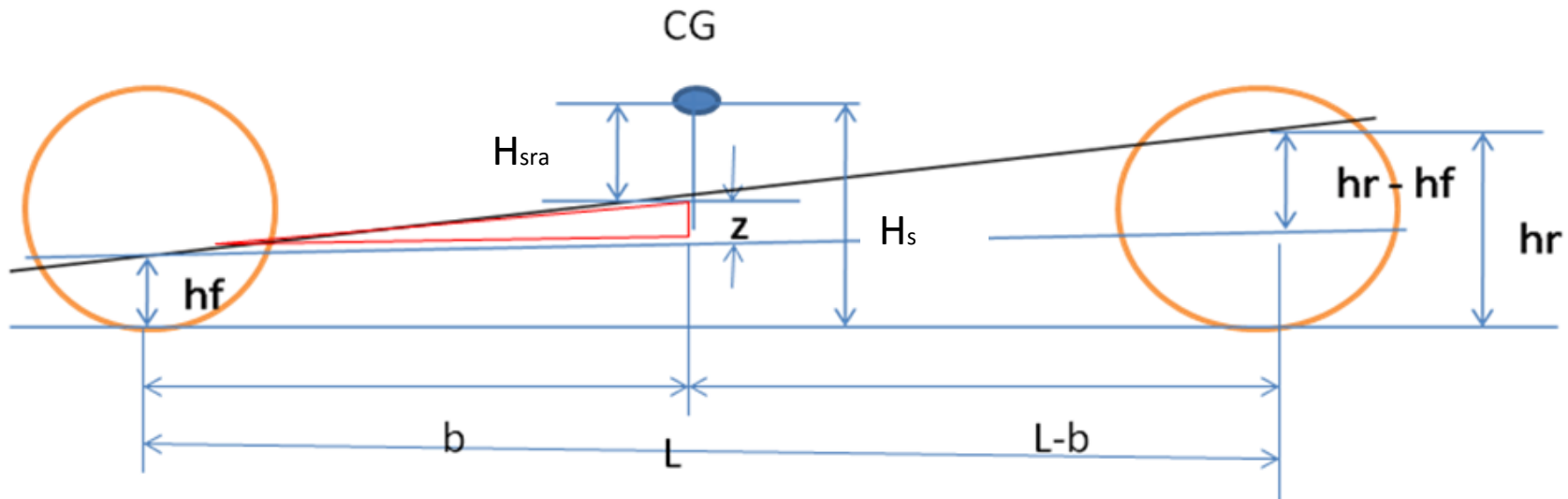
Substituting for F_{sr} gives

$$WT_{srl} = \frac{T_s^2 \phi K_{sr}}{2 \times T_r} \quad \text{Eqn 12}$$

Example 2 Data

T_f	Front track	1.270 m
T_r	Rear track	1.335 m
T_s	Spring track	0.96m
L	Wheel base	2.351 m
H_s	Sprung mass CG height above ground	0.374 m
H_{sra}	Sprung mass CG height above Roll axis	m
M_{sf}	Front sprung mass	312 kg
M_{sr}	Rear sprung mass	328 kg
M_{usf}	Front total unsprung mass	76 kg
M_{usr}	Rear total unsprung mass	88 kg
r	Rolling radius of tyre	0.275m
h_f	Front RC height	95 mm
h_r	Rear RC Height	238 mm
K_{wr}	Rear wheel rate	29,155 N/m
K_{wf}	Front wheel rate	60 025 N/m
SL_f	Front suspension leverage	1.83
a_y	Lateral acceleration	6m/s ²
Front suspension - unequal length double wishbones		
Rear suspension - live axle		

Finding the Height of CG above roll axis



Example to find CG height above roll axis

As an example assume:

$M_f = 300 \text{ kg}$	Total rear scale reading
$M_r = 342 \text{ kg}$	Total front scale reading
$L = 2351 \text{ mm}$	Wheelbase
$H_s = 340 \text{ mm}$	Height of CG of sprung mass above ground
$h_f = 95 \text{ mm}$	Front rc height
$h_r = 238 \text{ mm}$	Rear rc height

$$642 * b = 2351 * 342$$

Giving $b = 1255 \text{ mm}$ from the front wheel ie the length of the red triangle

CG height above roll axis

- By similar triangles therefore:

$$\frac{143}{2351} = \frac{Z}{1255}$$

- Giving $Z = 76 \text{ mm}$ Where Z is the height of the triangle at the position of the CG
- The height of the CG above the ground H' is 340mm
- This give a value of

$$H = 340 - (76 + 95) = 169 \text{ mm}$$