

Weight Transfer Calculation Example2

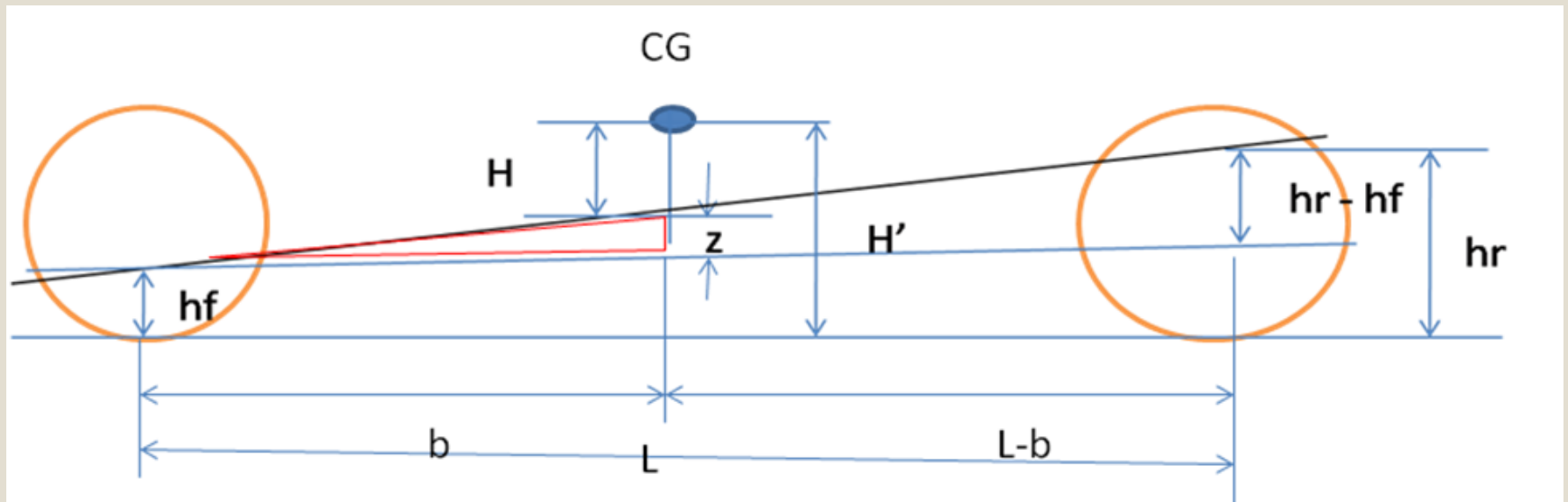
Example 2 Data

T_f	Front track	1.270 m
T_r	Rear track	1.335 m
L	Wheel base	2.351 m
H_{tot}	Total mass CG height above ground	0.3538 m
H_s	Sprung Mass CG Height above ground	 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

Review of method to find the height of CG above roll axis



Example to find CG height above roll axis calculation

As an example assume:

$M_f = 300 \text{ kg}$ Total front scale reading

$M_r = 342 \text{ kg}$ Total rear 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

Example of calculation of 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_s is 340mm
- This give a value of

$$H_{sra} = 340 - (76 + 95)$$

$$H_{sra} = 169 \text{ mm}$$

Find H_{sra}

1. Find Height of CG of sprung mass above the ground H_s (using moments – car vertical)
2. Find dimension b the distance of the CG from the front axle (using moments – car horizontal)
3. Using similar triangles find the height of the roll axis at b from the front axle.
4. Find the height of the CG of the sprung mass above the roll axis H_{sra}

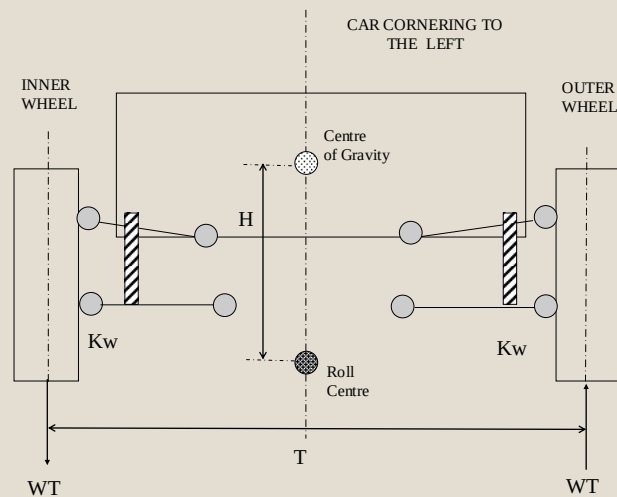
Hsra

- $H_s =$
- $H_{sra} =$

Roll Stiffness - Front

Roll stiffness of an independent suspension

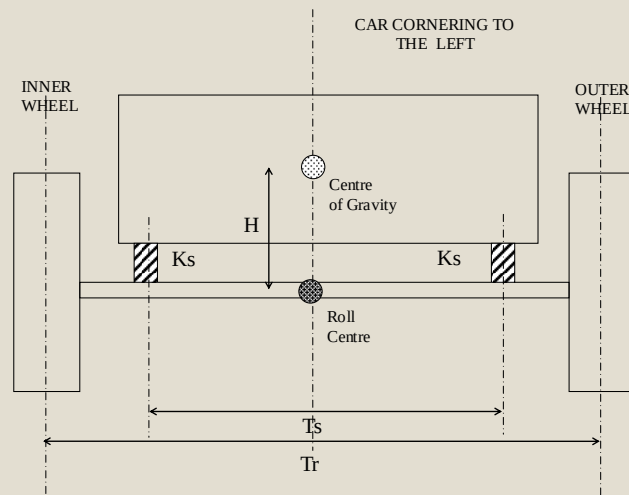
$$K_{\phi} = \frac{(T^2 \times K_w)}{2}$$



Roll Stiffness - Rear

$$K_{\phi r} = \frac{(T_{sr}^2 \times K_{wr})}{2}$$

Nm/Rad



Total Roll Stiffness for the Car

Total roll stiffness for the car = $K_{\phi t}$

$$K_{\phi t} = K_{\phi f} + K_{\phi r}$$

Roll Angle

The roll angle produced by a lateral acceleration of $a_y = \theta$ Radians

$$\theta = \frac{M_{ot}}{K_{\phi t}} \quad \text{Rad}$$

$$M_{ot} = M_s \times a_y \times H_{src} \quad \text{Nm}$$

$$K_{\phi t} = K_{\phi f} + K_{\phi r} \quad \text{Nm/ Rad}$$

Solutions to example so far

- $K_{\phi f} = 12473.12 \quad \text{Nm/rad}$
- $K_{\phi r} = 13434.62 \quad \text{Nm/rad}$
- $K_{\phi t} = 25907.74 \quad \text{Nm/rad}$
- $M_{ot} = 2738.549 \quad \text{Nm}$
- $\Theta = 0.0105 \quad \text{rad (ie } 0.6056 \text{ deg)}$

Resulting wheel load 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:

$$F_{sr} = \frac{\theta \times T_s \times K_{sr}}{2}$$

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

To Find the Weight Transfer Reacted at the Rear Wheels

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

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

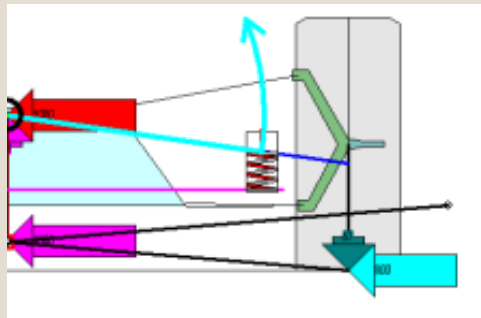
Substituting for F_{sr} gives

$$WT_{srl} = \frac{T_s^2 \times \theta \times K_{sr}}{2 \times T_r} = 105.665 \text{ N}$$

Elastic weight transfer WT_{sf} due to sprung mass at the front of the car

$$WT_{sf} = \frac{\theta \times T_f \times K_{wf}}{2}$$

$$WT_{sf} = 400.217 \text{ N}$$



Geometric weight transfer due to sprung mass WT_{src}

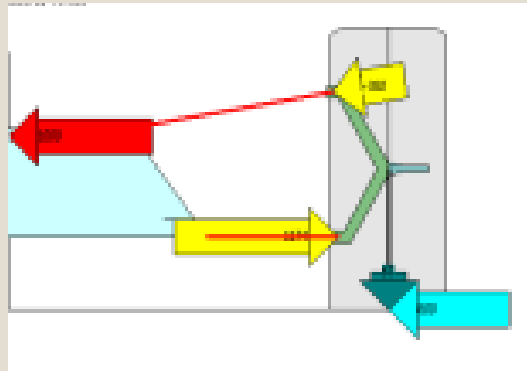
$$WT_{srcf} = \frac{M_{sf} \times a_y \times hf}{T_f}$$

$$WT_{srcr} = \frac{M_{sr} \times a_y \times hr}{T_r}$$

Results for WT_{srcf} and WT_{srcr}

$$WT_{\text{srcf}} = 105.02$$

$$WT_{\text{srcr}} = 302.71$$



Weight transfer due to the unsprung mass

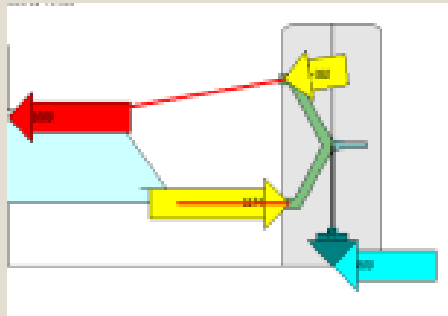
$$WT_{usf} = \frac{M_{usf} \times a_y \times r}{T_f}$$

$$WT_{usr} = \frac{M_{usr} \times a_y \times r}{T_r}$$

Results for WT_{usf} and WT_{usr}

$$WT_{usf} = 98.74 \text{ N}$$

$$WT_{usr} = 108.76 \text{ N}$$



Total weight transfer

The total weight transfer is then found from

$$\begin{aligned}\text{Front} &= WT_{sf} + WT_{srcf} + WT_{usf} \\ &= 432 + 105 + 98.74 = 636.3 \text{ N}\end{aligned}$$

$$\begin{aligned}\text{Rear} &= WT_{srl} + WT_{srcr} + Wt_{usr} \\ &= 105.67 + 302.71 + 108.76 = 517.1 \text{ N}\end{aligned}$$

$$\text{Total} = 1153.44 \text{ N}$$

Check value

$$WT = \frac{M_{tot} a_y H_c}{T}$$

$$H_c = 0.35 \text{ m} \quad M_{tot} = 681 \quad T_{mean} = 1.302 \text{ m}$$

This will only work if the CG Height used is for the combined sprung and unsprung masses.

$$WT = 1097.7$$

This is around 50 N less than that found by combining front and rear weight transfers – due to rounding errors
Using a spreadsheet would give more accurate result

Final individual corner loads

Corner ←

Front ↑

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

Finding Front outer wheel load F_{zof} for example data

$$\text{Static load per wheel} = (M_{sf}/2 + M_{usf}/2) \times 9.81$$

$$\text{Front Static Load} = 1520.5 \text{ N}$$

$$\text{Rear Static Load} = 1819.76 \text{ N}$$

Total Wheel load F_{zof}

$$\text{Total Wheel Load} = 1520 + 636.1 = 2156.85 \text{ N}$$

Static load +/- Total front weight transfer

Results for individual wheel loads

$$F_{zif} = 884.25 \text{ N}$$

$$F_{zof} = 2156.85 \text{ N}$$

$$F_{zir} = 1302.62 \text{ N}$$

$$F_{zor} = 2336.9 \text{ N}$$

Effect of Load Splits Produced

Left Turn Symmetrical												
					45.5%							
					LF+RF							
					3041.1							
			13.2%	LF	RF	32.3%						
Front Split	LF-RF	-1272.6	884.25			2156.9						
	LF+LR	32.7%	2186.9			6680.6	4493.8	67.3%	RF+RR			
(LR-RR) - (LF-RF)		238.3	19.5%				35.0%					
Rear Split	LR-RR	-1034.3	1302.6			LR	RR	2336.9				
LR-LF Split			418.4		3639.5	180.1	RR-RF Split					
Wedge			51.8%		LR+RR							
LR-RF Split			-854.2		54.5%							