

BSc /HND Automotive and Motorsport Engineering

Data Acquisition and Dynamics

Session 6

Finding CG Heights and Check Values

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Check value

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

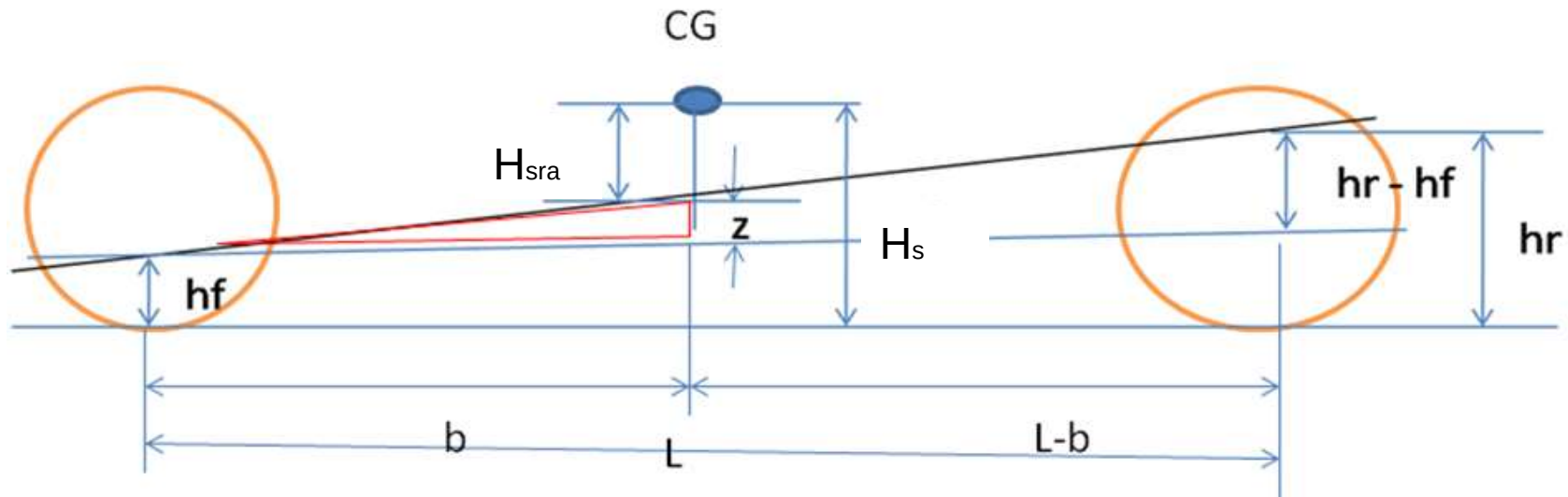
$$WT = \frac{M_t a_y H_t}{T}$$

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

Process needed to find H_t from Example 1 Data

- In normal practice the height of the CG of the total car H_t will be found in the workshop
- The height of the CG of the sprung mass H_s can then be calculated
- H_{sra} can be found knowing h_f and h_r
- Example 1 was simplified so that H_{sra} was given.
- So for this exercise we need to work backwards from H_{sra} to find H_s and then H_t

Finding the H_s the Height of CG of sprung mass above ground



Finding H_s CG height of sprung mass above ground

Using the data from Example 1

M_f	= 312 kg	Total front sprung mass
M_r	= 328 kg	Total rear sprung mass
L	= 2248mm	Wheelbase
H_{sra}	= 350mm	Height of CG Sprung mass above roll axis
H_s	= ?	Height of CG of sprung mass above ground
h_f	= 10mm	Front roll centre height
H_r	= 50 mm	Rear roll centre height

Finding CG height of sprung mass above ground

Take moments about the front wheel to find dimension b , the distance of the CG of sprung mass from front axle

$$640 * b = 2248 * 328$$

$$b = 1152.1$$

Giving $b = 1152.1$ mm from the front wheel (ie the length of the red triangle)

CG height of sprung mass above ground H_s

By similar triangles :

$$\frac{h_r - h_f}{L} = \frac{Z}{b}$$
$$\frac{40}{2248} = \frac{Z}{1152.1}$$

Giving $Z = 20.5 \text{ mm}$

Where Z is the height of the roll axis above the front roll centre height at the position of the CG of the sprung mass

The height of the CG above the roll axis is given as 350 mm

This give a value of H_s the height of CG of the sprung mass above ground of $350 + 20.5 + 10 = 380.5 \text{ mm}$

Overall CG height

To find the equivalent check value for a solid car we now need to find the CG height H_t of the total mass above the ground .

By taking moments about a horizontal axis :

$$H_t \times M_t = (M_{us} \times H_{us}) + (M_s \times H_s)$$

$$H_t \times 770 = (130 \times 277) + (640 \times 380.5)$$

$$H_t = 362.69\text{mm}$$

Solid car weight transfer check

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

$$WT = \frac{770 \times 6 \times 362.69}{(1270 + 1335) \times 0.5} = 1286.1 \text{ N}$$

This compares with **1284.4 N** for the distributed weight transfer found originally.

(The small difference can be accounted for by errors introduced when different front and rear tracks are used)

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}). In Example 1 you were given total front and rear masses so they need to be divided by 2 when finding the individual wheel loads.

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

Front outer wheel load F_{zof}

Total front weight transfer = 586.7 N

Total wheel load

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

$$= 1824.7 + 586.7 \text{ N}$$

$$= 2411.4 \text{ N}$$

The other wheel loads can now be found

Results for individual wheel loads

$$F_{zif} = 1237.9 \text{ N}$$

$$F_{zof} = 2411.4 \text{ N}$$

$$F_{zir} = 1254.5 \text{ N}$$

$$F_{zor} = 2649.9 \text{ N}$$

Example 2

The following example can now be worked through.

The data provided is more realistic in terms of the data that would be obtained in practice.

Example 2 Data

T_f	Front track	1.270 m
T_r	Rear track	1.335 m
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	30 mm
h_r	Rear RC Height	60 mm
K_{sr}	Rear spring rate	60,000 N/m
K_{sf}	Front spring rate	55 000 N/m
SL_f	Front suspension leverage	1.83
SL_r	Rear suspension leverage	1.6
a_y	Lateral acceleration	6m/s ²
Front and rear suspension - unequal length double wishbones		

Procedure

1. $H_{sra} = 0.3286 \text{ m}$
2. $K_{wf} = 16\,423 \text{ N/m}$
3. $K_{wr} = 23\,437 \text{ /mN/m}$
4. $K_{\phi f} = 13\,244.7 \text{ Nm/rad}$
5. $K_{\phi r} = 20\,885.5 \text{ Nm/rad}$
6. $\Phi = 0.0370 \text{ rad}$
7. $W_{tsf} = 385.9 \text{ N}$
8. $W_{tsr} = 578.9 \text{ N}$
9. $W_{tusf} =$
10. $W_{tusr} =$
11. $W_{Tsrcf} =$
12. $W_{Tsrcr} =$
13. $W_{Tf \text{ total}} =$
14. $W_{Tr \text{ total}} =$
15. Find Wheel Load Distribution