

Load Transfer

VEHICLE SYSTEMS

A solid orange horizontal bar spanning the width of the slide, located at the bottom.

What is Load Transfer?

It is the 'shifting' of weight around a vehicle during acceleration

This include under braking and deceleration

It is a crucial concept in understanding vehicle dynamics



Load Transfer

About 80% of vehicle handling relates to load transfer

The characteristics of load transfer can be affected by;

- Spring rates
 - Anti roll bars
 - Dampers
 - Ride height & roll centre height
 - Weight distribution, front and rear
 - Weight distribution, centre of gravity height
- 

Cornering



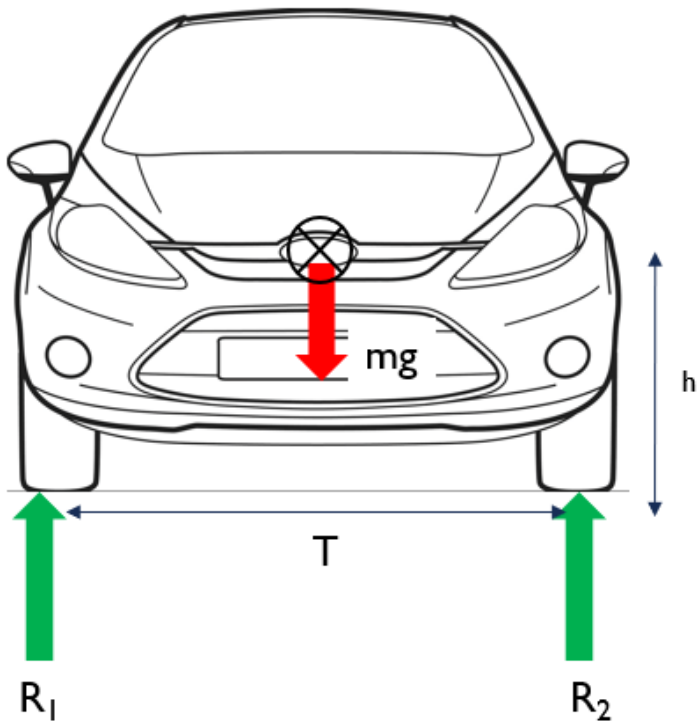
Why would a car travelling at a steady speed around a corner be subjected to an acceleration??

Due to **Cornering Force**

Will the load on the inside and outside tyres be different?

Due to **Lateral Load Transfer**

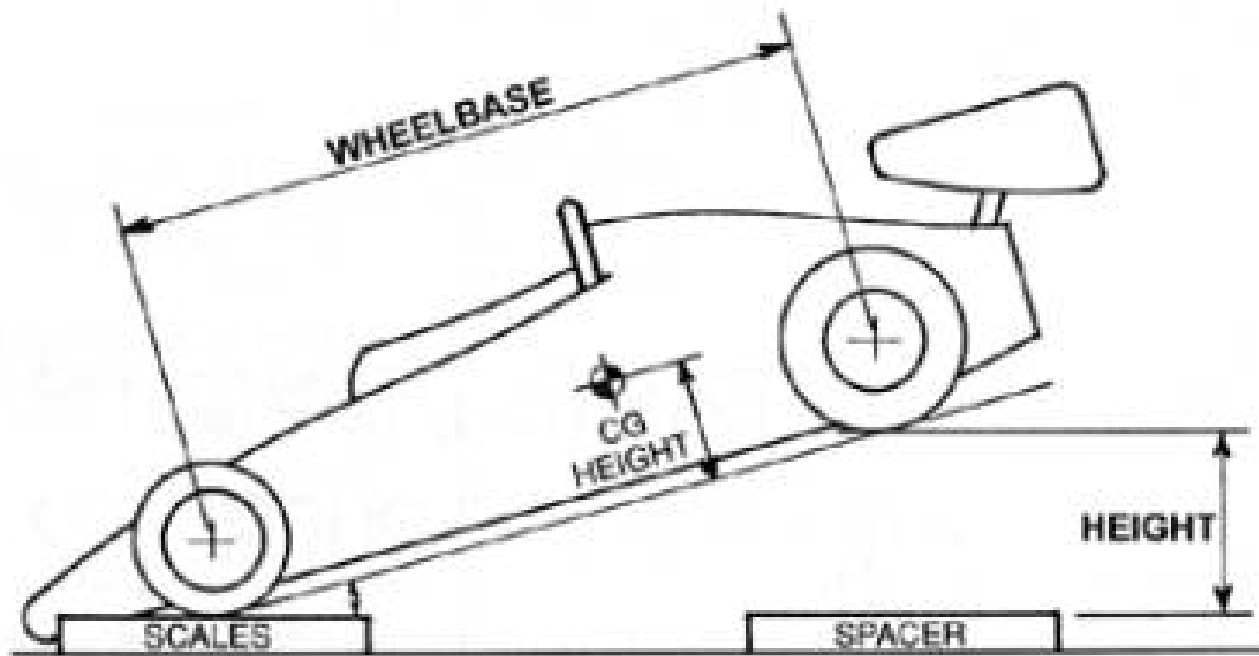
Load Transfer



$$\text{Load Transfer} = \frac{\text{Cornering Force} * \text{Height of Centre of Gravity}}{\text{Track Width}}$$

First of all need to calculate value for h ?

Height of Centre of Gravity



Height of CoG

It is very important to know the height of the centre of gravity

1) Put the vehicle on corner weight scales and record the Total Front Mass

2) Raise the rear of the car to between 15 ° and 20 ° from the horizontal

- - to calculate the height to lift the rear

$$\sin(\theta) \times \text{Wheel Base} = \text{Height Raised}$$

3) In new position, take note of the new Front Raised Mass

Height of CoG

4) Calculate the Front Axle Mass change; i.e. the difference between the Total Front Mass and the Front Raised Mass

5) Calculate the Centre of Gravity Height above the axle;

$$\text{CoG Height above the axle} = \frac{\text{Wheel base} * \text{Front Axle Mass Change}}{\text{Total Mass} * \tan(\theta)}$$

6) Calculate the Centre of Gravity Height above the ground;

$$\text{CoG Height above the ground} = \text{Axle Height} + \text{CoG Height above the axle}$$

Example

1) Total Front Mass = 180kg

- Total Mass = 425kg

2) Wheelbase = 2.65m. Therefore height to raise car if aiming for 18 degree angle;

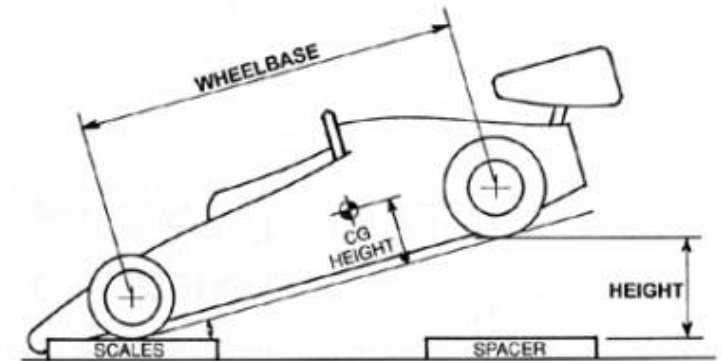
- $\sin(18) * 2.65 = 0.819m$

3) Total Front Raised Mass = 188kg

4) *Front Axle Mass Change* = $188 - 180 = 8kg$

5) *CoG Height above Axle* = $\frac{2.65 * 8}{425 * \tan(18)} = 0.1535m$

6) *CoG Height above Ground* = $0.24 + 0.1535 = 0.3935m$



Example 1

Centre of Gravity

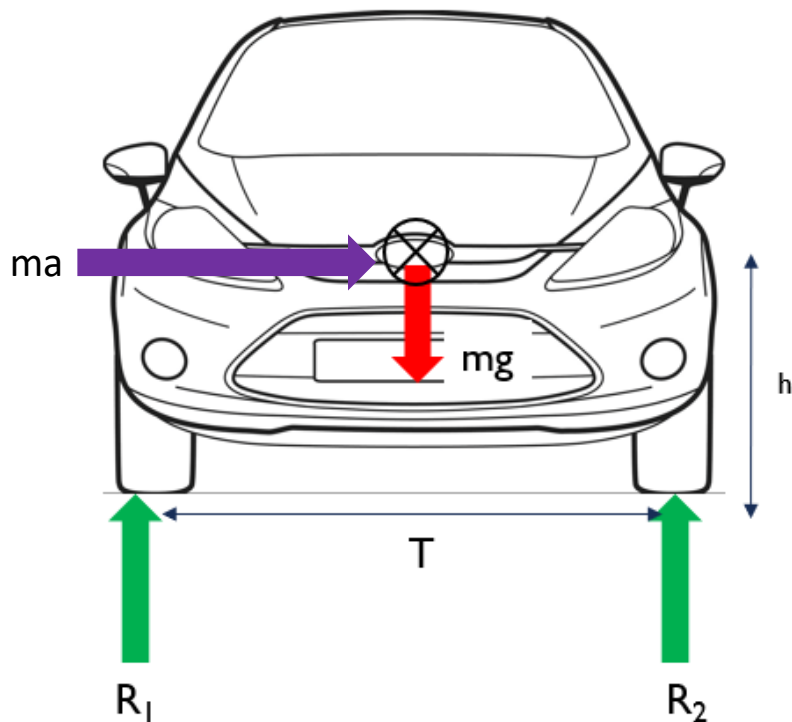
There is a vehicle with a total mass of 500 kg and a front total mass of 210kg. The wheel base of this vehicle is 2.5m.

A) What height does it need to be raised to to achieve an angle of 17.5° ?

B) If the total raised mass change is 8.5kg, what is the Centre of Gravity height above the axle?

C) If the axle height is 0.25m, what is the Centre of Gravity height above the ground?

Load Transfer



$$\text{Load Transfer} = \frac{\text{Cornering Force} * \text{Height of Centre of Gravity}}{\text{Track Width}}$$

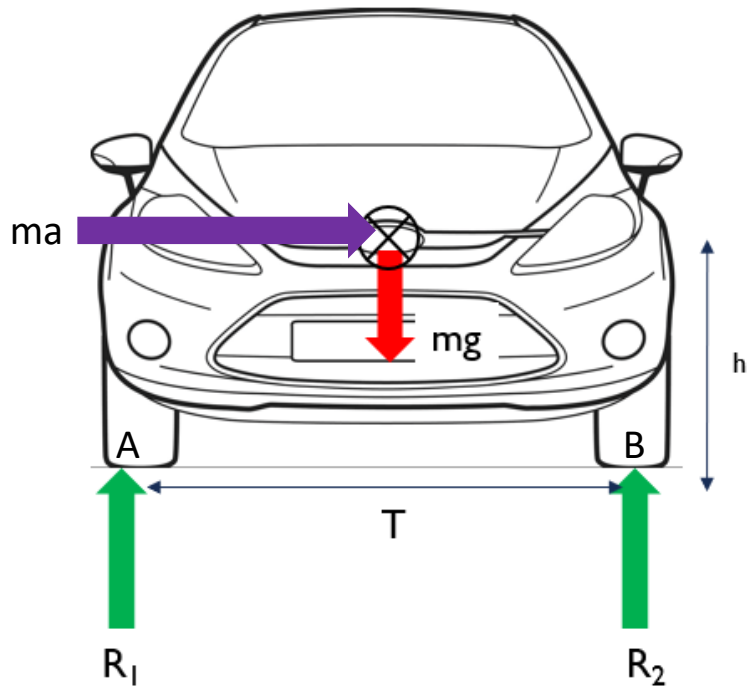
Now we need to calculate the Cornering Force?

A vehicle that is cornering will have a lateral acceleration, a

Now what are the loads on the inside and outside tyres

Cornering Force – Lateral Load

Need to take moments about A and B.

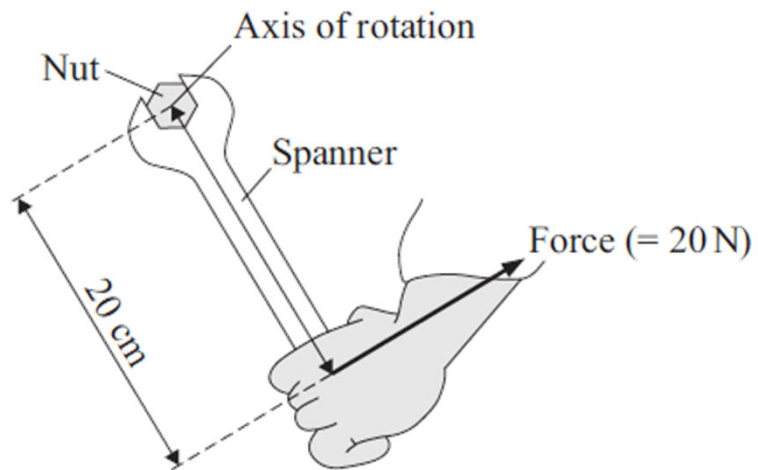


Taking Moments

The moment of a force is a measure of its tendency to cause a body to rotate about a specific point or axis.

$$\text{Moment} = \text{Force} \times \text{Distance}$$

$$M = Fd$$

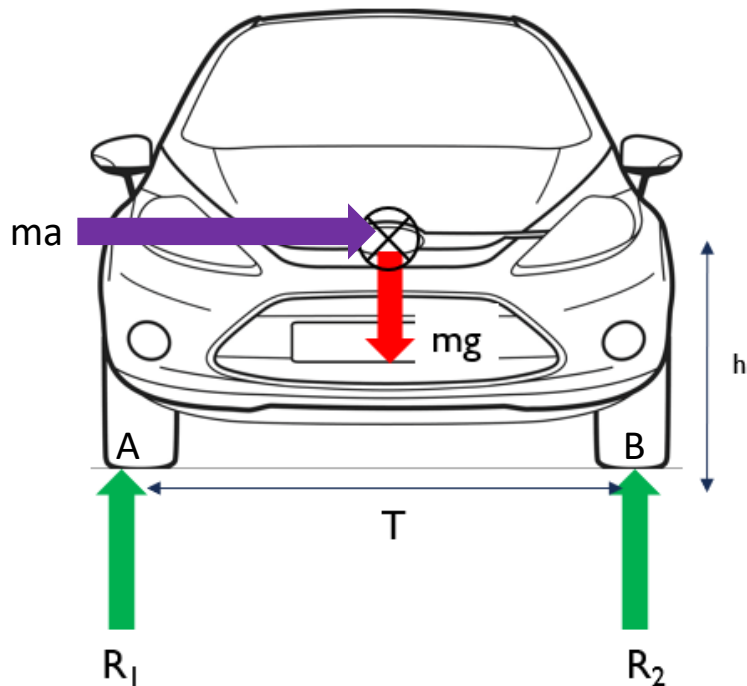


$$\text{Force} = 20\text{N}$$

$$\text{Distance} = 20\text{cm} = 0.2\text{m}$$

$$\begin{aligned}\text{Moment} &= 20 \times 0.2 \\ &= 4\text{N}\end{aligned}$$

Cornering Force – Lateral Load



Need to take moments about A and B.

Start with A;

Clockwise moments, $cwm = \frac{mgT}{2} + mah$

Anticlockwise moments, $acwm = R_2T$

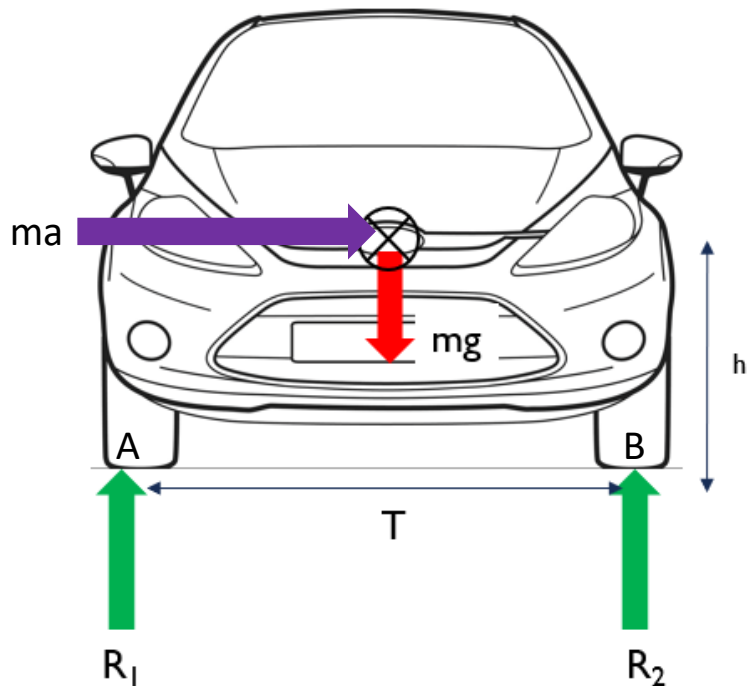
Therefore; $cwm = acwm$

$$\frac{mgT}{2} + mah = R_2T$$

Rearrange for R_2

$$R_2 = \frac{mg}{2} + \frac{mah}{T}$$

Cornering Force – Lateral Load



Need to take moments about A and B.

Start with B;

Clockwise moments, $cwm = R_1T + mah$

Anticlockwise moments, $acwm = \frac{mgT}{2}$

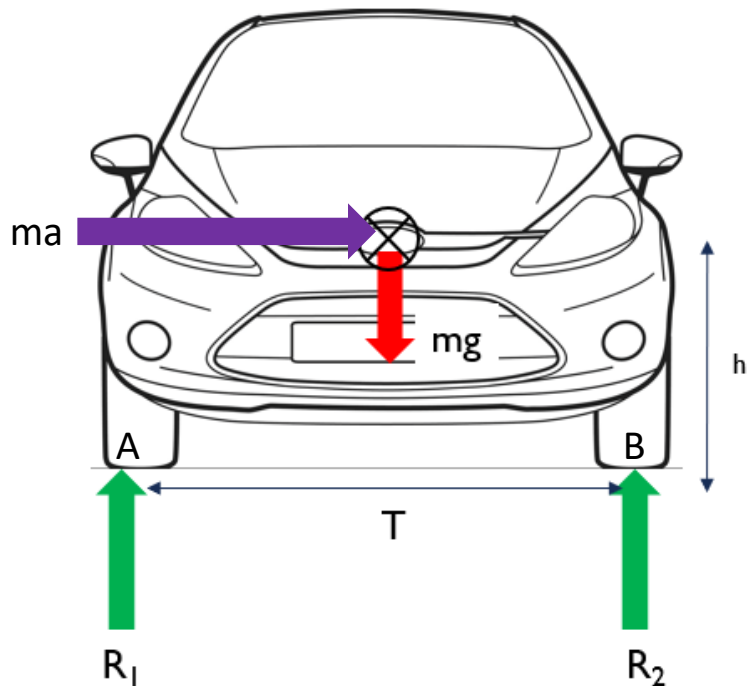
Therefore; $cwm = acwm$

$$R_1T + mah = \frac{mgT}{2}$$

Rearrange for R_1

$$R_1 = \frac{mg}{2} - \frac{mah}{T}$$

Cornering Force – Lateral Load



Need to take moments about A and B.

$$R_1 = \frac{mg}{2} - \frac{mah}{T}$$

$$R_2 = \frac{mg}{2} + \frac{mah}{T}$$

The section of the equation that changes depending on side is

$$\frac{mah}{T}$$

Therefore Lateral Load Transfer = $\pm \frac{mah}{T}$

Example 2

Lateral Load Transfer

A car is going around a corner with a cornering force of 11 025N and has a track width of 1.5m. The centre of gravity height is 0.325m above the ground.

What is the Lateral Load Transfer?

Example 3

Lateral Load Transfer

A vehicle of mass 1500kg is subjected to an acceleration of 8m/s^2 as it goes around a corner. It has a track width of 1.35m and a centre of gravity height above the ground of 0.38m.

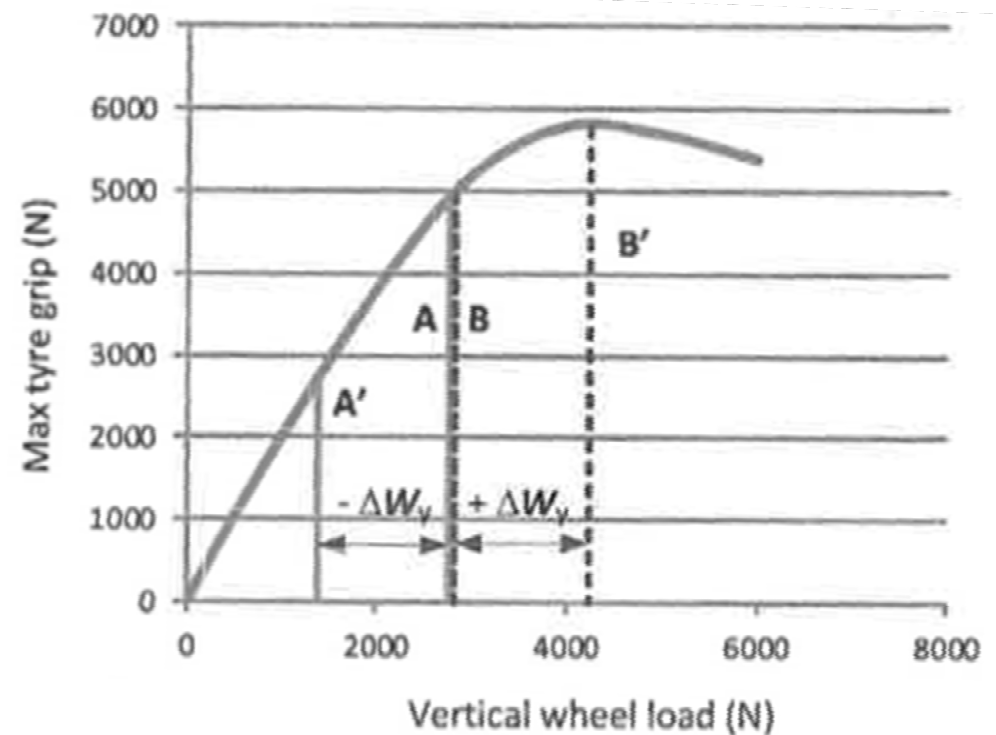
What is the Lateral Load Transfer?

Load Transfer & Overall Grip

How is the load distributed?

This is a tyre grip curve.

Can you explain what the graph shows?



Cornering with a Force 'G'

Often in Motorsport, it is said that a car is cornering with a lateral acceleration given in 'G' i.e 0.9g

How do we use this value in our calculations?

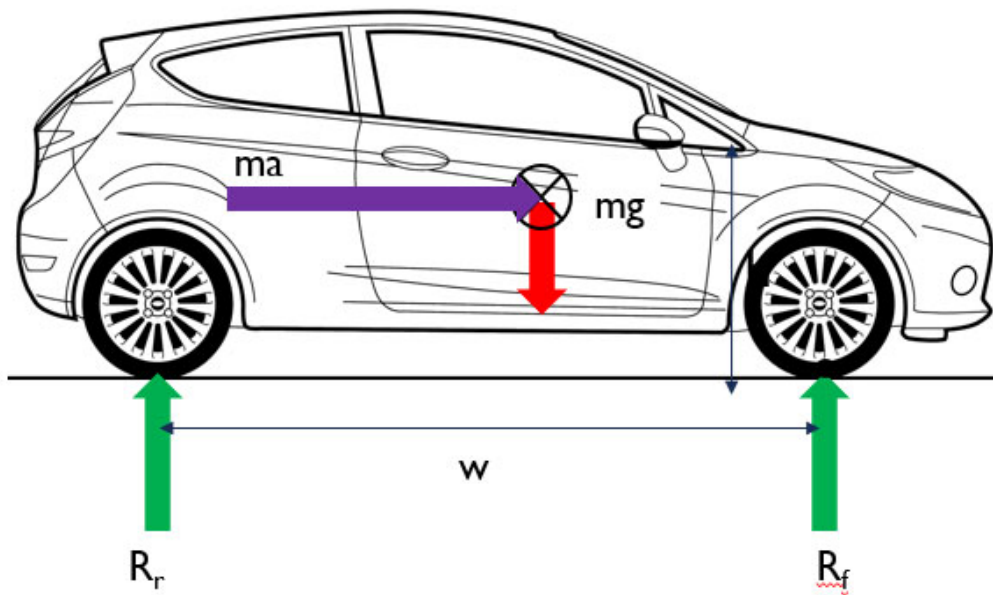
A vehicle of mass 825kg is experiencing a lateral acceleration of 0.9g. The trackwidth of the vehicle is 1.28m and the CoG height is 0.32m. What is the load transfer?

$$\text{Lateral Load Transfer} = \frac{mah}{T} = \frac{825 * (0.9 * 9.81) * 0.32}{1.28} = \frac{2330.86}{1.28} = 1820.98N$$

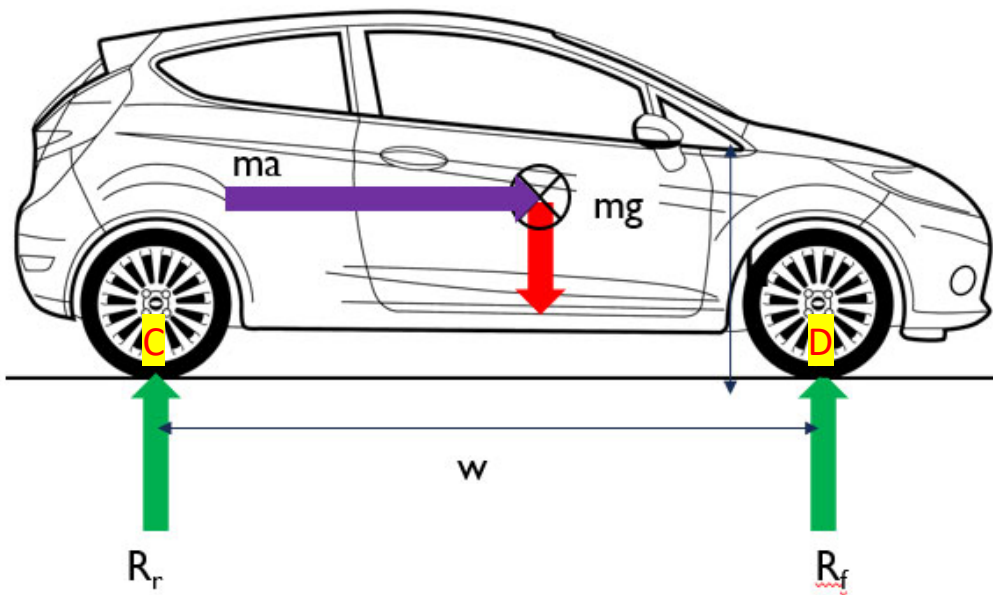
Longitudinal Load

Accelerating and braking cause Longitudinal Load Transfer

Differences to Lateral Load, is that we consider the wheel base, w , not the track width, T



Longitudinal Load



Take Moments about C

$$cwm = acwm$$

$$mah + \frac{mgw}{2} = R_f w$$

$$R_f = \frac{mah}{w} + \frac{mg}{2}$$

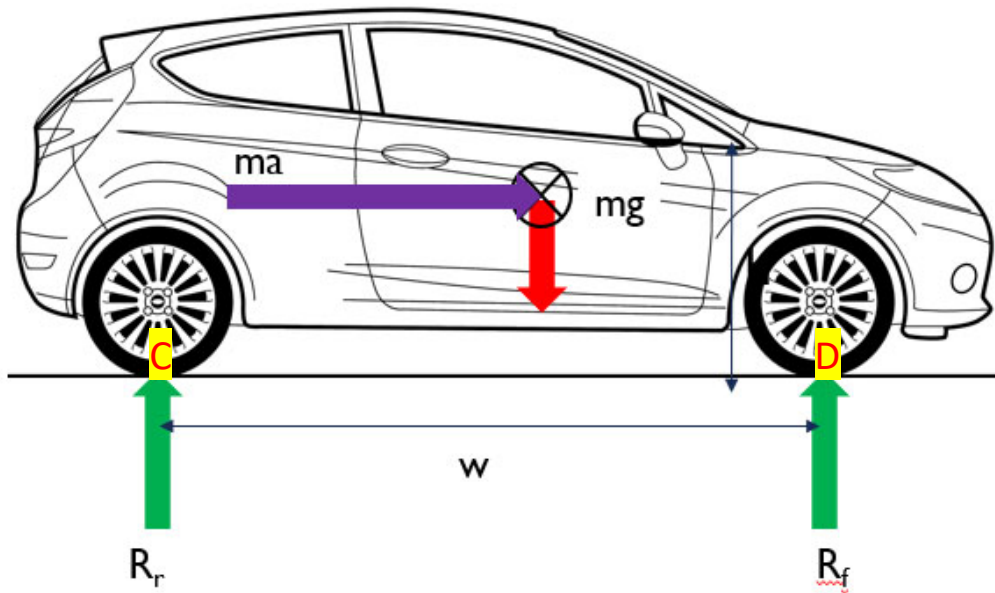
Take Moments about D

$$cwm = acwm$$

$$R_r w + mah = \frac{mgw}{2}$$

$$R_r = \frac{mg}{2} - \frac{mah}{w}$$

Longitudinal Load



$$\text{Longitudinal Load Transfer} = \pm \frac{mah}{w}$$

When accelerating,

...the longitudinal load is added to rear static load & subtracted from front axle load

When braking...

...the opposite happens, and load is added to the front axle and subtracted from the rear load

What are **Squat** and **Dive**?

Example 4

Longitudinal Load Transfer

- a) A vehicle that has a mass of 749.2kg and is accelerating at 14.5m/s^2 . If the wheel base of the vehicle is 3.215m and the CoG Height is 0.325m what is the Longitudinal Load Transfer?
- b) The same vehicle is now braking with a deceleration of 10.2m/s^2 , what is the Longitudinal Load Transfer now?