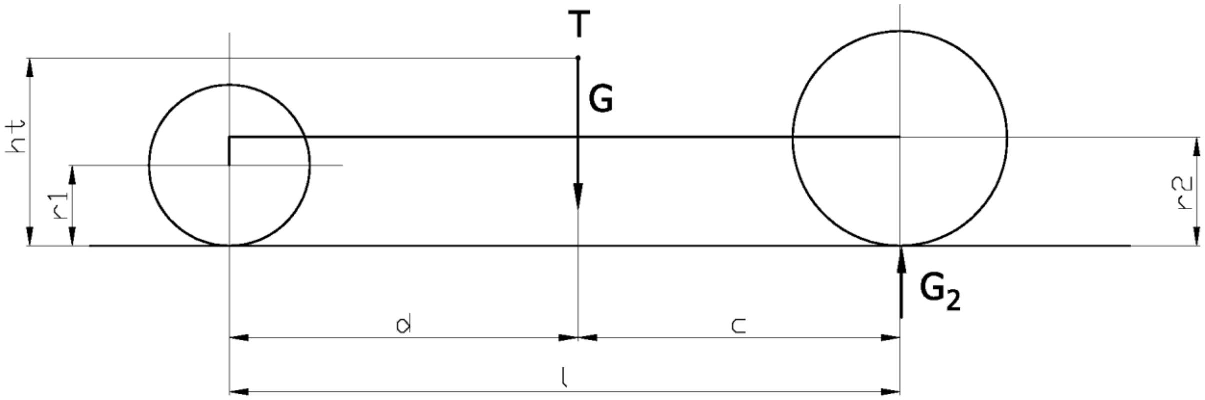
Vehicle Centre of gravity

Example:
Find the horizontal and vertical position of the car's center of gravity. The vertical position of the center of gravity was determined by measuring the vertical reaction of gravity with the front axle raised.

Define:
m = 1400 kg vehicle mass
r_1 = 300 mm front wheel radius
r_2 = 400 mm rear wheel radius
l = 2500 mm wheelbase
g = 9,81 $m.s^{-2}$ gravity acceleration
h = 800 mm front axle stroke when determining the vertical position of the center of gravity
G_2 = 7142 N vertical reaction of the rear wheel in the horizontal position of the vehicle
G_2' = 7789 N vertical reaction of the rear wheel with the front axle raised

***Calculation of the horizontal position of the center of gravity*.**
The horizontal position of the center of gravity is determined at the horizontal position of the vehicle from the known weight (weight) of the vehicle, the weight (weight) of one of the axles and the wheelbase.



If we know the weight of the vehicle and the vertical force from the rear wheel, then from the condition of moment balance to the axis O_1 we can write:

$$G \cdot d = G_2 \cdot l$$

Vehicle Gravity G:

$$G = m \cdot g = 1400 \cdot 9{,}81 = 13734 \text{ [N]}$$

then:

$$d = \frac{G_2 \cdot l}{G} = \frac{7142 \cdot 2500}{13734} = 1300 \text{[mm]}$$

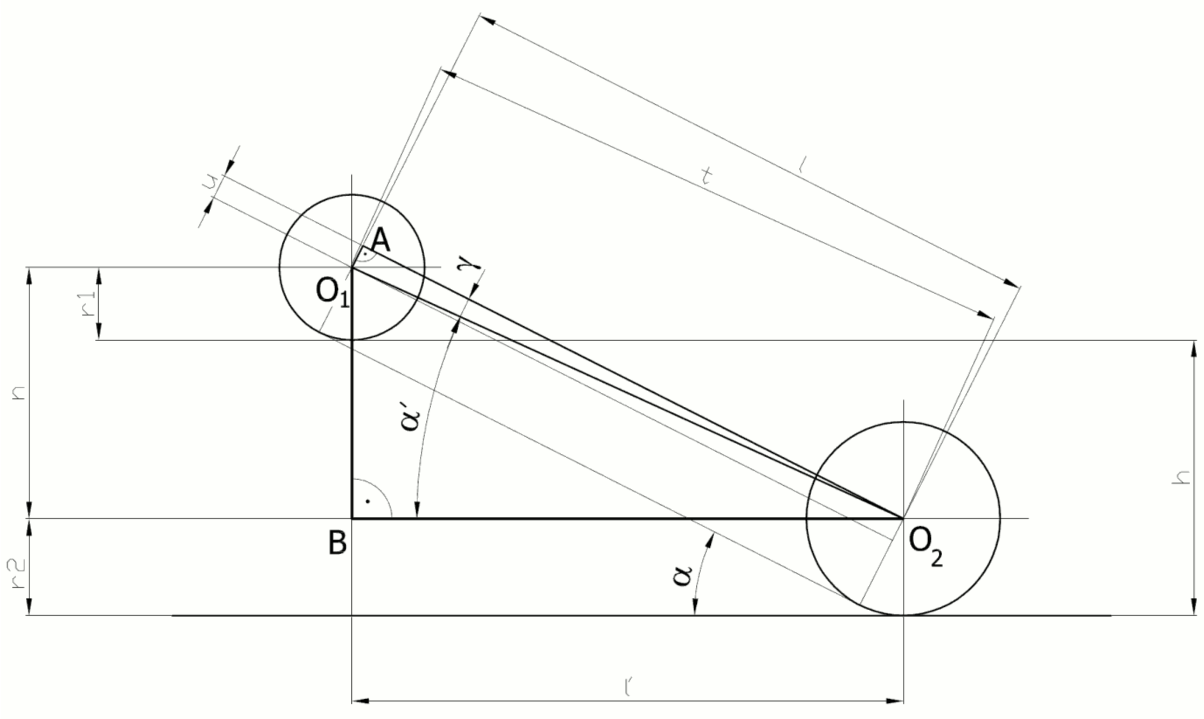
Calculation of the vertical position of the center of gravity.

The vertical position of the center of gravity is determined from the response value of one of the axles if the vehicle is inclined at an angle of inclination α.

Measurement conditions:
The wheels must be released
The suspension should be secured in the neutral position
Reactions can only act in the vertical direction
We need to know the horizontal position of the center of gravity

The angle of inclination of the vehicle can be found either:
Using a plumb line and a caliper
Calculated from the axle stroke

Calculation of the inclination angle α:



from perpendicular triangles (O_1 O_2 B) a (O_1 O_2 A)
for α:

$$\alpha = \alpha' + \gamma$$

for α':

$$tg\alpha' = \frac{n}{l'}$$

for γ :

$$\gamma = arctg\frac{u}{l} = arctg\frac{100}{2500} = 2{,}291°$$

for n :

$$n = h - r_2 + r_1 = 800 - 400 + 300 = 700 \ \text{[mm]}$$

for l' :

$$l'^2 = t^2 - n^2$$

for t :

$$t^2 = l^2 + u^2$$

For u :

$$u = r_2 - r_1 = 400 - 300 \ \text{[mm]}$$

then l' can write:

$$l'^2 = l^2 + u^2 - n^2$$

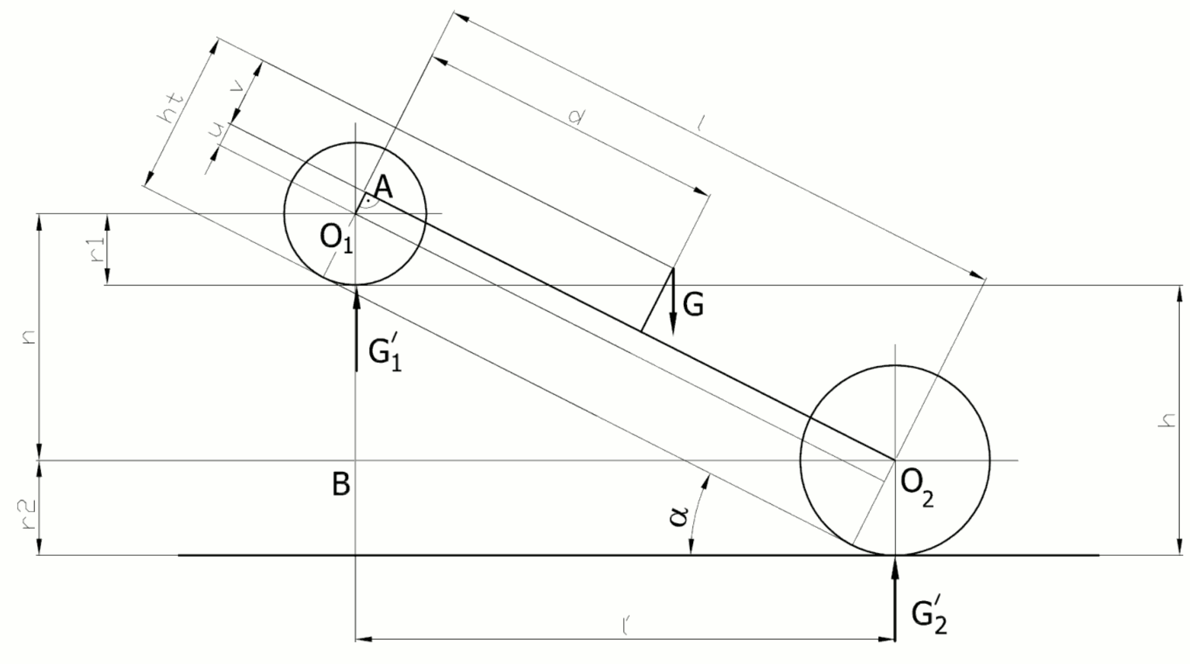
$$l' = \sqrt{l^2 + u^2 - n^2} = \sqrt{2500^2 + 100^2 - 700^2} = 2402 \ \text{[mm]}$$

Then α':

$$\alpha' = arctg\frac{n}{l'} = arctg\frac{700}{2402} = 16{,}247°$$

Then α:

$$\alpha = \alpha' + \gamma = 16{,}247 + 2{,}291 = 18{,}937°$$



We write the condition of the moment-to-point balance O_1:

$$G \cdot (u \cdot \sin\alpha + d \cdot \cos\alpha + v \cdot \sin\alpha) = G_2' \cdot (u \cdot \sin\alpha + l \cdot \cos\alpha)$$

$$u \cdot \sin\alpha + d \cdot \cos\alpha + v \cdot \sin\alpha = \frac{G_2'}{G} \cdot (u \cdot \sin\alpha + l \cdot \cos\alpha)$$

$$v \cdot \sin\alpha = \frac{G_2'}{G} \cdot (u \cdot \sin\alpha + l \cdot \cos\alpha) - u \cdot \sin\alpha - d \cdot \cos\alpha$$

$$v = \frac{G_2'}{G} \cdot (u + \frac{l}{tg\alpha}) - u - \frac{d}{tg\alpha}$$

when:

$$v = h_t - r_2$$

then:

$$h_t = v + r_2 \quad h_t = \frac{G_2'}{G} \cdot (u + \frac{l}{tg\alpha}) - u - \frac{d}{tg\alpha} + r_2 = \frac{7789}{13734} \cdot \left(100 + \frac{2500}{tg 18{,}937°}\right) - 100 - \frac{1300}{tg 18{,}937°} + 400 = 700 \text{ [mm]}$$