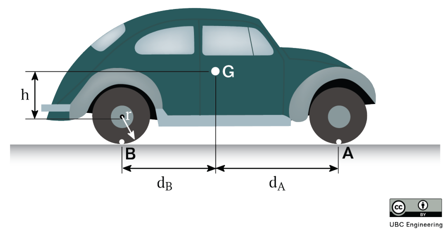
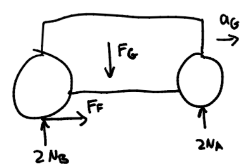
20-R-KIN-DK-17

A punch buggy is challenged to race. As it starts from rest, slamming on the accelerometer causes the rear wheels to slip. If the punch buggy has a mass of $m = 1440\ kg$ with a centre of gravity at G, determine the distance it would travel in $t = 5\ seconds$ and the normal force on each of its four wheels. Assume the mass of the wheels are negligible, and the coefficients of static and kinetic friction are $\mu_s = 0.45$ and $\mu_k = 0.2$, respectively. The radius of both wheels is $r = 0.2\ m$. G is a height of $h = 0.5\ m$ from the bottom of the frame, and $d_A = 2\ m$ and $d_B = 1.5\ m$.



Solution

Setting up the equations of motion:



$\sum F_x: \quad F_F = \mu_k(2N_B) = m(a_G)_x$ due to slipping and for both back wheels
$\sum F_y: \quad 2N_A + 2N_B - mg = m(a_G)_y = 0 \implies N_A + N_B = 1440 \cdot 9.81/2 = 7063.2\ N$

$$\sum M_A = m(a_G)_x\, d: \quad mg(d_A) - 2(N_B)(d_A + d_B) = m(a_G)_x\,(h + r)$$
$$1440 \cdot 9.81(2) - 2(N_B)(3.5) = 1440(a_G)_x\,(0.7)$$
$$7N_B = 28252 - 1008(a_G)_x$$

where the sign is determined by the right hand rule (counter clockwise about A is negative)

Now solving for N_B and $(a_G)_x$:

$\mu_k(2N_B) = m(a_G)_x \implies N_B = \frac{1440}{0.4}(a_G)_x = 3600(a_G)_x$

$7N_B = 28252 - 1008(a_G)_x \implies 7(3600(a_G)_x) = 28252 - 1008(a_G)_x$

$(a_G)_x = 1.168 \quad [\text{m/s}^2]$
$N_B = 4204 \quad [\text{N}]$

$N_A = 2859 \quad [\text{N}]$

Finally applying the kinematic equation for motion $\Delta s = v_0 t + \frac{1}{2}at^2$:

$\Delta s = 0(5) + \frac{1}{2}(1.168)(5^2) = 14.6 \quad [\text{m}]$