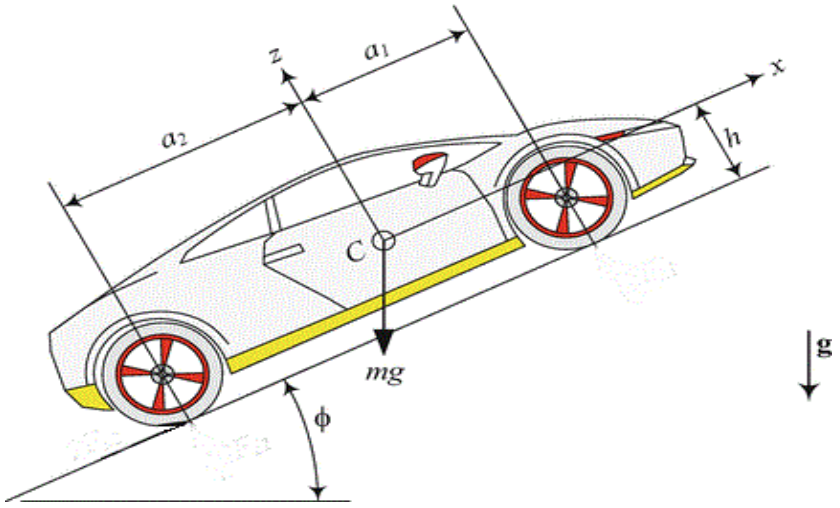
SUPERHOMEWORK #2

A car is climbing an inclined road as shown in the figure. The car engine exerts a constant couple T on the rear wheels. All wheels weigh equally m_w and the body weighs m. For simplicity, we consider the motion is completely symmetrical about x-axis. We assume air resistance is negligible.

(hint: Because of symmetry, this problem can be solved like a 2-D motorcycle problem just the front wheel and rear wheel weighs $2m_w$. See video of Example 9 of the General Plane Motion for more details)



a) Assume wheels roll without slipping on the road and drive all equations of the motion (for body, rear and front wheels).

b) Develop a computer code in MATLAB that receives $m, m_w, a_1, a_2, h, \phi$, T, r (radius of each wheel) and generates the following outputs:

- Friction between the road and front and rear wheels.
- Normal reactions on front and rear wheels by the road.
- Acceleration of the car and angular acceleration of the wheels.
- Forces exerted on front and rear axles.

c) Run your computer code and present your results for numerical values listed in the table (Check if the wheels slip or not ($\mu_s = 0.8,\ \mu_k = 0.6$) and change equations if required).

	$m\ (kg)$	$m_w\ (kg)$	$a_1\ (m)$	$a_2\ (m)$	$h\ (m)$	$\phi\ (deg)$	$T\ (N.m)$	$r\ (m)$
1	500	15	1.8	1.5	0.8	0	200	0.35
2	500	15	1.8	1.5	0.8	2	200	0.35
3	500	15	1.8	1.5	0.8	10	600	0.35
4	500	15	1.8	1.5	0.8	5	900	0.35

d) Use the data listed in the second row of the table for constant parameters and pure rolling condition to

- Plot a (acceleration) *versus* m (body mass)
  $300\ kg \leq m \leq 800\ kg$

- Plot a *versus* r (wheel radius)
  $0.25\ m \leq r \leq 0.5\ m$

- Assume $a_1 + a_2$ is constant and equal to 3 meters ($a_1 + a_2 = 3$ m). Define $\frac{a_1}{a_2} = n$ and $q = \frac{F_1}{F_2}$
  F_1: Force applied to the front axle
  F_2: Force applied to the rear axle
  Plot q *versus* n
  $0.5 \leq n \leq 2$

- Plot $\mu_s . N_{rear\ wheel}$ and $f_{rear\ wheel}$ *versus* T on the same axes.
  $300\ N.m \leq T \leq 1000\ N.m$

  For which value of the couple the rear wheel starts to slip (T_{slip})?

- Assume the couple changes from $300\ N.m$ *to* T_{slip} linearly in 30 seconds.
  Plot Velocity *versus* time $(V_0 = 0), (0 < t < 30\ s)$.