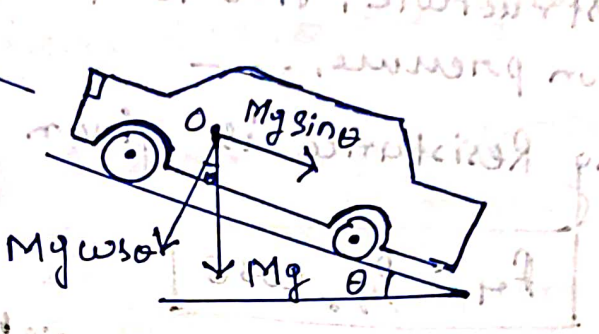
Assignment

Q. Derive the equation of motion and maxm tractive effort for a car inclined at angle θ. Also give the expression of maximum gradeability for a 4 wheel drive.

Soln



Consider a vehicle of Mass M moving at a velocity of V at an inclination of angle θ.

as shown in above figure,

Vehicle resistances opposing its movement including rolling Resistance of the tire as rolling resistance torques T_{rf} and T_{rr}, aerodynamic drag, F_w, and hill climbing resistance,

a) Aerodynamic drag

Aerodynamic drag is given by

$$F_w = \frac{1}{2} \rho A_f C_D (V)^2.$$

Where, V = Vehicle speed

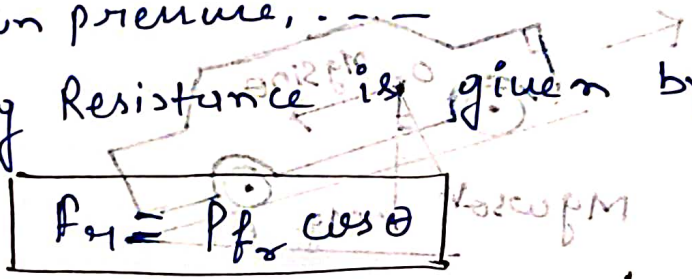
A_f = frontal area

ρ, air density

C_D : aerodynamic drag co-efficient.

b) Rolling Resistance.

The rolling resistance co-efficient, f_r, is a function of the tire material, tire structure, tire temperature, tire inflation pressure, ---



Rolling Resistance is given by :-

$$F_R = P f_r \cos\theta$$

Where, f_r = rolling resistance co-efficient

c) Grading Resistance :-

When a vehicle goes up or down a slope, its weight produces a component that is always directed in the downward direction.

Grading resistance, can be expressed as

$$F_g = M_v g \sin\theta$$

Dynamic Equation of Vehicle Motion in the longitudinal direction is expressed by:-

$$Ma = (f_{tf} + f_{tr}) - (f_{rf} + f_{rr} + f_w + f_g)$$

where, f_{rf}, f_{rr} are rolling resistance of the front and rear tires.

Tractive effort of the front and rear tires are given as- f_{tf}, f_{tr}

f_{tf} is zero, when its rear wheel drive

f_{tr} is zero, when its front wheel drive.

Tractive effort is

$$f_T (f_{tf} + f_{tr})$$

$$f_T = Ma + f_{rr} + f_w + f_g$$

$$F_T = Ma + \overrightarrow{Mg} f_r \cos\theta + Mg \sin\theta$$

$$\boxed{F_T = Ma + Mg\left[f_r \cos\theta + \sin\theta\right]}$$

Gradeability is usually defined as the grade that a vehicle can overcome at a certain constant speed.

Q2

Consider a car with the following specifications that is parked on a level road. Find the load on the front and rear axles, m = 1765kg,

$I = 2.84m$,

$a_1 = 1.22m$

$a_2 = 1.62m$

Soln

Axle load on ~~front~~ Rear $= W \frac{a_1}{I}$ where, $W = mg$

$= 1765 \times 9.8$

$= 17297 N$

Axle load on ~~rear~~ front $= W \frac{a_2}{I}$

$W_f = W \frac{a_1}{I} = 17297 \times \frac{1.22}{2.84} = 7,430.4 N$

$= 7.4 kN$

$W_f = W \frac{a_2}{I} = 17297 \times \frac{1.62}{2.84} = 9,866.5 N$

$= 9.8 kN$

Q3 What are the different parts of tires? Differentiate b/w types of tires on the basis of their construction.

Soln The main component of Tire are explained below :-

Bead or bead bundle :- it is a loop of high strength steel cable coated with rubber. it give the tire the strength need to stay seated on the wheel rim.

Inner layer :- Made up on different fabrics, called piles

cap_piles :- polyesterid fabric that help hold everything in place.

cap pile are not found on all tires ; they are mostly used on tires with higher speed rating.

Inner layers :- specially compounded rubber that forms the inside of a tubeless tire, it inhibits loss of air pressure.

Belts or belt buffers :- one or more rubber - coated layers of steel, polyester, nylon, Kevlar around the tire under the thread

Carcass :- Supports the tension forces generated by tire air pressure made up of rubber - coated steel or other high strength cords tied to bead bundles.

Sidewall :- provides lateral stability, protect the body piles and helps to keep the air from escaping from the tire.

tread :- portion of tire that is in contact with the Road.