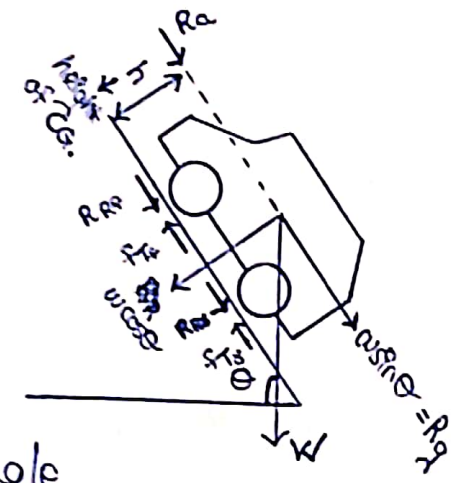
Q.1. Derive the equation of motion and maximum tractive effort for a car inclined at angle θ. Also give the expression of maximum gradeability for a 4 wheel drive.



- Aerodynamic Resistance (R_a):

$$R_a = \frac{1}{2} \times \rho \times C_d \times A \times V^2.$$

- Gravitational Resistance / Gradient Resistance (R_g):

$$R_g = W \sin\theta.$$

$\theta \rightarrow$ Inclination angle / gradient angle.

min. $(\theta = 0^\circ) \rightarrow R_g = 0.$

max. $(\theta = 90^\circ) \rightarrow R_g = W.$

- Rolling Resistance (R_R):

$$R_R = R_{Rf} + R_{Rr}.$$

- Traction Force (F_T):

$$F_T = F_{Tf} + F_{Tr}. \rightarrow \text{AWD / 4WD.}$$

$$F_T = F_{Tf} \rightarrow \text{Front wheel drive.}$$

$$F_T = F_{Tr} \rightarrow \text{Rear wheel drive.}$$

Hence $F_T - (R_a + R_R + R_g) = ma$

$$F_T = \underbrace{ma}_{\text{Acc. Resistance}} + \underbrace{R_a + R_R + R_g}_{\text{Resistive Forces}}.$$

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Q.1. Derive the equation of motion and maximum tractive effort for a car inclined at angle θ. Also give the expression of maximum gradeability for a 4 wheel drive. (cont.)

Maximum tractive effort that the tire-ground contact can support :

$$F_{t\,max} = \mu W_f = \mu \left[\frac{L_b}{L} w \cos\theta - \frac{h}{L} \left(F_{t\,max} - F_x \left(1 - \frac{r_d}{h}\right)\right)\right]$$

$$F_{t\,max} = \mu W_r = \mu \left[\frac{L_a}{L} w \cos\theta - \frac{h}{L} \left(F_{t\,max} - F_x \left(1 - \frac{r_d}{h}\right)\right)\right]$$

Tractive effort that the maximum torque of the power plant can produce with the given driveline gear ratios.

Gradeability :

$$\frac{T_T i_o i_g \eta_t}{r_d} = M_r g w f_r + \frac{1}{2} \rho_d C_D A_f V^2 + M_r w i.$$

$$i = \frac{(T_p i_o i_g \eta_t / r_d) - M_r w f_r - \frac{1}{2} \rho_d C_D A_f V^2}{w} = d - f.$$

$$d = \frac{F_t - F_w}{w} \rightarrow \text{performance factor}$$

$$= \frac{(T_p i_o i_g \eta_t / r_d) - \frac{1}{2} \rho_d C_D A_f V^2}{w}$$

$$\sin\theta = \frac{d - f_r \sqrt{1 - d^2 + f_r^2}}{1 + f_r^2}.$$

Q.2. Consider a case with the following specifications that is tasked on a level road. Find the load on the front and rear axles. $m = 1765$ kg. $l = 2.84$ m. $a1 = 1.22$ m. $a2 = 1.62$ m.

Load on the front $= mg \frac{a_2}{l}$

$= 1765 \times 9.807 \times \frac{1.62}{2.84}$

$= 9873.65$ N

$= 9.87$ kN.

Load on the rear $= mg \frac{a_1}{l}$

$= 1765 \times 9.807 \times \frac{1.22}{2.84}$

$= 7435.71$ N

$= 7.44$ kN.

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Q.3. What are the different parts of tires? Differentiate between types of tires on the basis of their construction.

A tyre consist of thread, sidewall, belt plies (steel), shoulder insert, inner liner, body plies, bead filler, bead and abrasion gum strip.

Thread: It is the portion of the tire that comes in directly with contact with the road. It should have higher strength and good heat dissipation property for good life of tyre.

Sidewall: It is the portion of tyre which is exposed to environment and not come in contact with road.

Belt Plies: They are two or more strong layers of cord just under the thread, providing strength and stability to the thread.

Shoulder: Outer edge of thread which wraps into the sidewall.

Inner Liner: Innermost layer of a tubeless tyre. It prevents flow of air from inside to outside and vice versa.

Body Plies: Gives tire strength and transmits cornering forces from thread to wheel.

Bead Filler: Rubber compound inside the tire's beads. Gives stability to the lower sidewall and bead area.

Beads: Holds tire to the rim

Types of tyre on the basis of construction:

Bias Ply / Cross Ply: Consist of carcass layers made of nylon cord which are placed diagonally along each other in the thread and sidewalls, at 50° angle.

Radial Ply: Consist of carcass ply formed by textile ares running one bead to another, at an angle of 90° to the rolling direction.

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