

Q.1. Derive the equation of motion and maximum tractive effort for a car inclined at angle  $\theta$ . 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 ( $R_R$ ):

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

- Traction Force ( $F_T$ ):

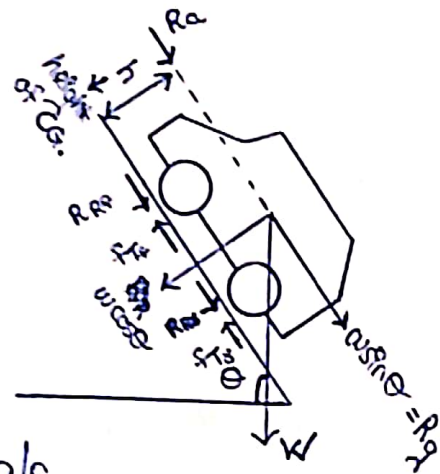
$$F_T = F_{Tf} + F_{Tx} \rightarrow \text{AWD / 4WD.}$$

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

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

$$\text{Hence } F_T - (R_a + R_R + R_g) = ma$$

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



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Q.2. Consider a car with the following specifications that is parked on a level road. Find the load on the front and rear axles.  $m = 1765 \text{ kg}$ .  $L = 2.84 \text{ m}$ .  $a_1 = 1.22 \text{ m}$ .  $a_2 = 1.62 \text{ m}$ .

$$\begin{aligned}\text{Load on the front} &= mg \frac{a_2}{L} \\ &= 1765 \times 9.807 \times \frac{1.62}{2.84} \\ &= 9873.65 \text{ N} \\ &= 9.87 \text{ kN}.\end{aligned}$$

$$\begin{aligned}\text{Load on the rear} &= mg \frac{a_1}{L} \\ &= 1765 \times 9.807 \times \frac{1.22}{2.84} \\ &= 7435.71 \text{ N} \\ &= 7.44 \text{ kN}.\end{aligned}$$

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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 tire consists of tread, sidewall, belt plies (steel), shoulder insert, inner liner, body plies, bead filler, bead and abrasion gum strip.

**Tread:** 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 properties for good life of tire.

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

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

**Shoulder:** Outer edge of tread which wraps into the sidewall.

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

**Body Pies:** Gives tire strength and transmits cornering forces from tread 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 tire 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 tread and sidewalls, at  $50^\circ$  angle.

**Radial Ply:** Consist of carcass ply formed by textile arcs running one bead to another, at an angle of  $90^\circ$  to the rolling direction.

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