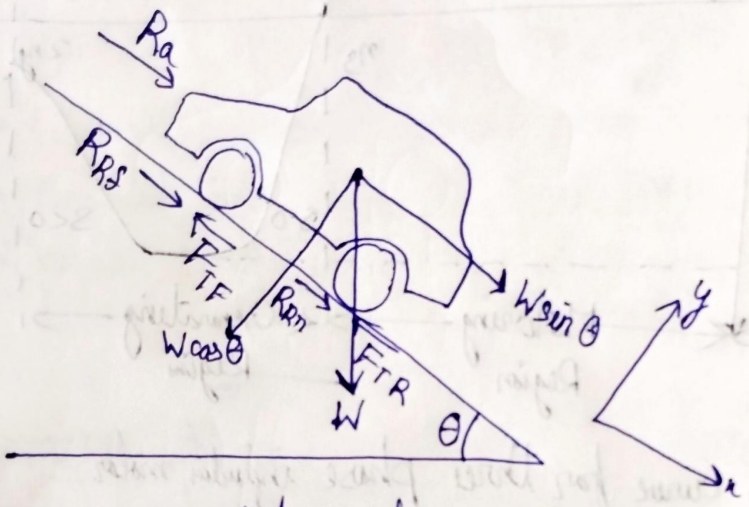
Assignment-2

1. Derive the Equation of motion and maximum tractive effort for a car inclined at angle θ. Also, give the expression of maximum gradability for a 4-wheel drive.

⇒



Writing the equation of force along x-axis,

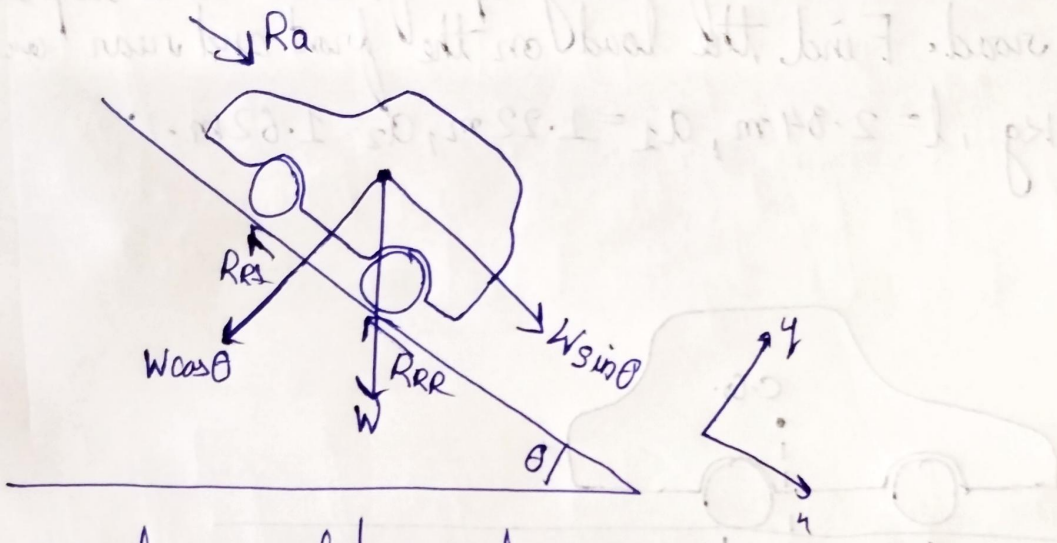
$$F_{TF} + F_{TR} - (R_a + W\sin\theta + R_{RF} + R_{RR}) = ma$$

$$\therefore F_{TF} + F_{TR} = ma + R_a + W\sin\theta + R_{RF} + R_{RR}$$

$$\Rightarrow \boxed{F_T = ma + R_a + W\sin\theta + R_R} \qquad (F_T = F_{TF} + F_{TR} \text{ \& } R_R = R_{RF} + R_{RR})$$

$$\Rightarrow F_T = ma + \frac{1}{2} \times \rho \times C_d \times A \times V^2 + W\sin\theta + H_R - W\cos\theta$$

$$\boxed{F_T = ma + \frac{\rho C_d A V^2}{2} + W\sin\theta + H_R - W\cos\theta}$$ (maximum tractive effort)



Solving for equilibrium along x-axis,

$$R_{Rf} + R_{Rr} - (R_a + W\sin\theta) = 0$$

$$R_R = R_a + W\sin\theta$$

$$H_R - W\cos\theta = \frac{1}{2}\rho \cdot C_d \cdot A \cdot V^2 + W\sin\theta$$

$$H_R - \frac{\rho \cdot C_d \cdot A \cdot V^2}{2} = \omega\cos\theta + W\sin\theta$$

$$(A\sin\theta + B\cos\theta = R\sin(\theta+\alpha))$$

where $R = \sqrt{A^2+B^2}$ and $\alpha = \tan^{-1}\frac{B}{A}$

$$\therefore H_R - \frac{\rho \cdot C_d \cdot A \cdot V^2}{2} = \sqrt{\omega^2+W^2}\sin(\theta+\alpha)$$

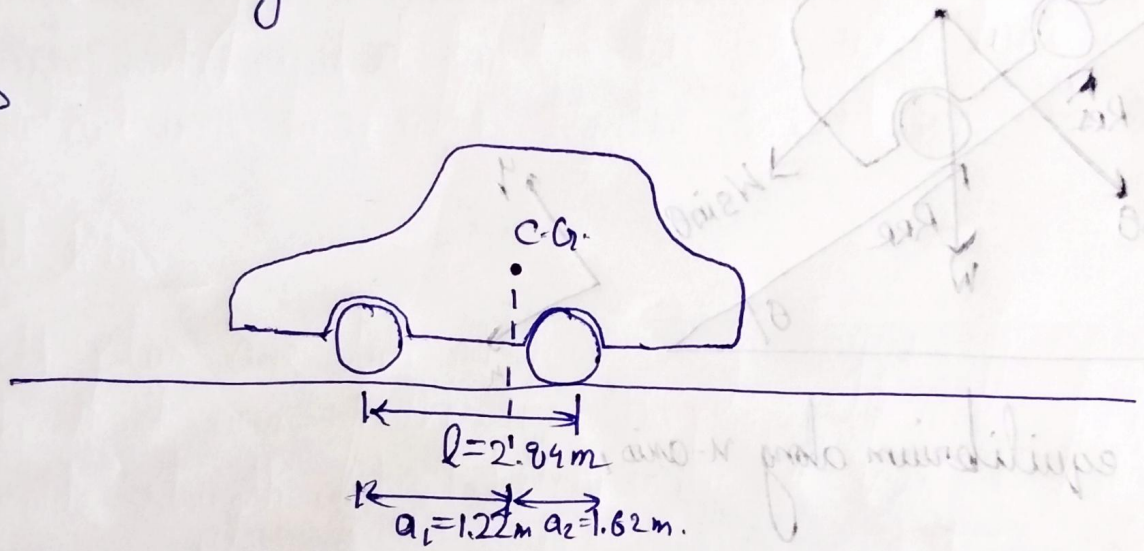
$$\Rightarrow \theta+\alpha = \sin^{-1}\left(\frac{2H_R - \rho \cdot C_d \cdot A \cdot V^2}{2\sqrt{\omega^2+W^2}}\right)$$

$$\Rightarrow \boxed{\theta = \sin^{-1}\left(\frac{2H_R - \rho \cdot C_d \cdot A \cdot V^2}{2\sqrt{\omega^2+W^2}}\right) - \tan^{-1}\left(\frac{\omega}{W}\right)}$$

2. Consider a car with the following specifications that is parked on a level road. Find the load on the front and rear axles.

$m = 1765$ Kg, $l = 2.84$ m, $a_1 = 1.22$ m, $a_2 = 1.62$ m.

⇒



$$m_f = (m \cdot a_1)/l$$

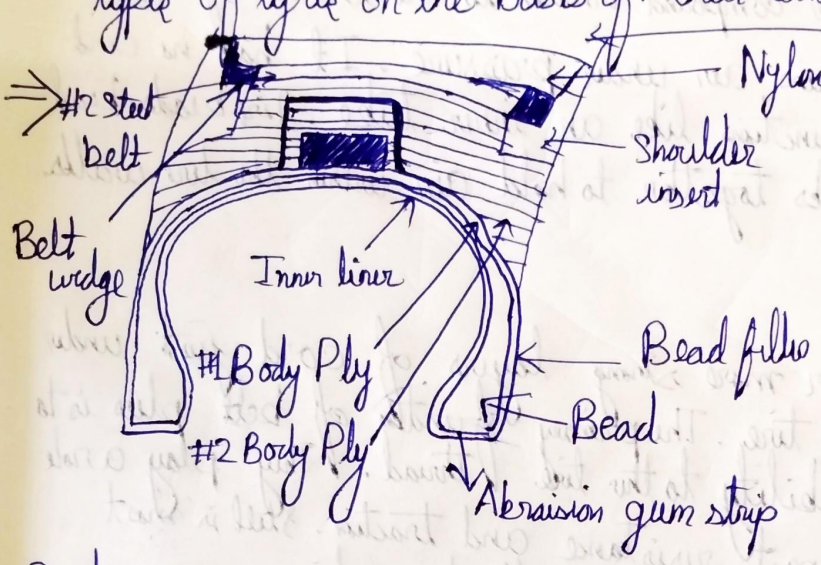
$$= \frac{1765 \times 1.22}{2.84} = 758.20 \text{ Kg}$$

$$m_R = m - m_s$$

$$= 1765 - 758.20 = 1006.8 \text{ Kg}$$

So, load on front axle is 758.20 Kg and load on rear axle is 1006.8 Kg.

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



Beads

Tire beads hold the tire to the rim or outer edge of the wheel. They're made up of copper, brass, or bronze-plated high tensile steel wires wound into a rubber band. Tire beads prevent the tires to slide when wheel rolls.

Bead Filler

Bead filler is a rubber compound inside the tire's beads. It provides stability to the lower side wall and bead area. The density and stiffness of a tire's bead filler help to determine the tire's performance characteristics.

Body plies

The body ply gives the tire strength and transmits cornering forces from the tread to the wheel. Rubber coated fabric cord, called body plies make up the cord body. Body plies can be made up of polyester, rayon, or nylon. Polyester is most commonly used.

Inner Liners

The inner liners are rubber compound bonded to the inside of the cord body that retains air under pressure. It has no cord reinforcement, and it functions like an inner tube. Tire beads, bead filler and inner liners works together to hold air within the tire walls.

Belt Plies

Belt plies are two or more strong layers of cord just under the thread area of the tire. The primary function of belt plies is to provide strength and stability to the tire thread. They play a role in improving tire milage, impact resistance and traction. Steel is most commonly used cord material used in belt ~~cross~~ plies.

Thread

The thread is the portion of the tire that comes in contact with the road surface. The thread compound and its design have to balance wear, traction, handling, fuel economy, resistance and other characteristics of the tire.

Radial Ply Tires	Biased Ply Tyres
– Radial tyres are made of steel belts running at 90° angle of the tire thread center line.	– Bias ply tyres, are built with nylon belts, which are made of criss cross rubber coated plies of nylon at 30°-75° of the thread center line
– Most radial tyres are resistant to penetration and cuts, especially in thread area.	– Bias-ply tyres are cut resistant to in the sidewall area. If there are any cuts in thread area, it can affect upto 35% of the tyre.
– The radial tyres have a stiffer thread and they distribute weight evenly. This results in steady and consistent contact patch and greater traction, means tyre wears less.	– In biased-ply tires the sidewall and crown in base-ply are independent. This makes the middle of the thread lifts up when the sidewall deflect. This leads to erosion of tire and shorter tyres life.