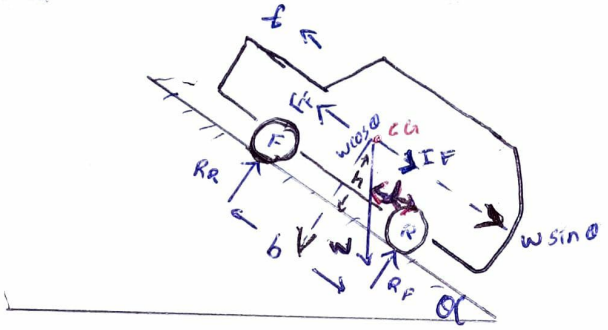
Assignment 2

1. Derive the eqn of motion & maximum tractive effort for a car inclined at angle θ. Also give the expression of max. gradeability for a 4 wheel drive.

Ans Considered a front wheel drive vehicle moving uphill



W : weight of the car

CG : centre of gravity

b : Wheel base

f - max. forward acceleration

F_F - max. tractive effort

R & F - Rear & front wheel

R_R, R_F - Total normal reaction at front & rear wheel

h - height from road surface to CG

IF - Inertia force (mass × acceleration) $= \frac{W}{g} f - W \sin\theta$ — (1) $(I_F = mf)$

At equilibrium condition

$\Sigma V = 0$

$W \cos\theta = R_R + R_F \quad - (2)$

$\Sigma H = 0$

$F_F = I_F + W \sin\theta \quad - (3)$

$F_F = \mu R_F$

$\mu R_F = \frac{W}{g} f + W \sin\theta$

$R_F = \frac{W}{g} \frac{f}{\mu} + \frac{W}{\mu} \sin\theta$

$R_F = \frac{W}{\mu} \left(\frac{f}{g} + \sin\theta \right) \quad - (4)$

Taking moment about R

$R_F \times b + (I_F \times h) = W \cos\theta \times d$

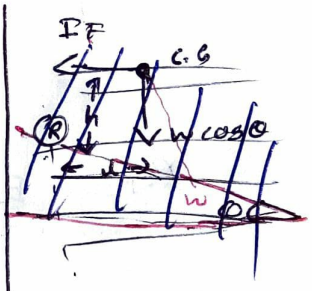
From (4)

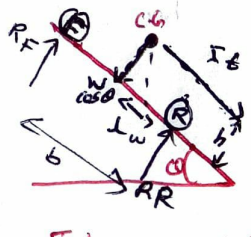
$\left(\frac{W}{\mu} \frac{f}{g} + \frac{W}{\mu} \sin\theta \right) b + \left(\frac{W}{g} f \sin\theta \right) h = W \cos\theta \, d$

$\left(\frac{f}{\mu g} + \frac{\sin\theta}{\mu} \right) b + \left(\frac{f}{g} + \sin\theta \right) h = \cos\theta \, d$

$I_F = f$

$F_F = (m f - W \sin\theta)$





Taking moment about R

R_F & I_F = anti clock wise

$W \cos\theta$ = clock wise direction

$$\frac{b}{\mu}\left(\frac{F}{g}+\sin\theta\right)+\left(\frac{F}{g}+\sin\theta\right)h = \cos\theta\, l$$

$$\left(\frac{b}{\mu}+h\right)\left(\frac{F}{g}+\sin\theta\right) = \cos\theta\, l$$

$$\frac{F}{g}+\sin\theta = \frac{\cos\theta\, l}{\frac{b}{\mu}+h} \quad -(5)$$

$$\frac{F}{g} = \left[\frac{\cos\theta\, l}{\left(\frac{b}{\mu}+h\right)}\right] - \sin\theta$$

$$F = g\left[\left[\frac{\cos\theta\, l}{\frac{b}{\mu}+h}\right] - \sin\theta\right] \quad -(6)$$

$$=$$

By Substituting $\frac{F}{g}+\sin\theta = \frac{\cos\theta\, l}{\frac{b}{\mu}+h}$ in (4)

we get,

$$R_F = \frac{w}{\mu} \times \frac{\cos\theta\, l}{\frac{b}{\mu}+h} \quad -(7)$$

$$= \frac{w\cos\theta\, l}{b+\mu h}$$

$$=$$

$$R_R = w\cos\theta - R_F$$

$$= w\cos\theta - \frac{w\cos\theta\, l}{b+\mu h}$$

$$= w\cos\theta\left[1-\frac{l}{b+\mu h}\right]$$

$$= W \cos\theta \left[\frac{b + \mu h - l}{b + \mu h} \right]$$

$$F_F = \mu R_F = \mu \times \left(\frac{W \cos\theta \, l}{b + \mu h} \right)$$

For four wheel drive vehicle

We know that,

$$F = F_R + F_F$$

$$= \mu R_R + \mu R_F$$

$$\Sigma V = 0 \quad \text{i.e.} \quad W = R_F + R_R$$

$$\Sigma H = 0$$

$$\frac{W}{g} f = \mu R_R + \mu R_F$$

$$= \mu (R_R + R_F) = \mu (W)$$

i.e. $\frac{F}{g} = \mu$

Assuming limiting friction occurs at all the four wheels simultaneously

Expression for maximum gradeability for a 4 wheel drive

$$P = 100 \left[\frac{F_z}{9.81 \cdot G_z} - b_R \right]$$

P = Gradeability in %

G_z = Overall combined mass in kg

b_R = coeb. of rolling resistance

F_z = Tractive force in N

2. Consider a car with the following specifications that is parked on a level road. Find the load on the front & rear axles. $m = 1765$ kg, $L = 2.84$ m

$a_1 = 1.22$ m, $a_2 = 1.62$ m

Ans

Load on Front axle

$$F_{Zf} = mg\left(\frac{a_2}{L}\right)$$

$$= 1765 \times 9.8 \times \frac{1.62}{2.84} = 9866.59 \text{ N}$$

Load on Rear axle

$$F_{ZR} = mg\left(\frac{a_1}{L}\right)$$

$$= 1765 \times 9.8 \left(\frac{1.22}{2.84}\right) = 7430.41 \text{ N}$$

3. What are the different parts of tires? Differentiate b/w types of tires based on construction.

Ans. 1) Bead : It holds the tire to the rim
It consist of high tensile steel wire strands.

2) Bead filler : Protect the tire from steel bead.

3) Inner liner : It is a soft rubber compound
Protect air from leaking

4) Body Ply : → Soft rubber compound with reinforcement.
→ It may be Neylon, Kevlar, carbon fiber etc.
→ Give structural strength to tire

5) Side wall : It is the side or external portion of tire

6) Tread : The top contacting portion of tire.
→ It contacts the road surface

7) Shoulder : In b/w side wall & tread the portion is called shoulder
→ It is a thinner portion

8) Shoulder inserts : These are inserted to provide strength for shoulder

9) Steel Belt : Used for reinforcement of tread.

Depending on construction the types

1) Bias plg
2) Radial plg

Bias plg

In this type of tyres that feature a bias plg placements, have the plies in their internal structure placed diagonally. This pattern angled at 30-40 degrees to the centre line.

→ Criss cross pattern

Radial Plg

Radial tyres feature structures where the plies are added at 90° angles from one bead to the other.

Bias Tyres	Radial Tyres
1) Thicker sidewalls	1) Minimal sidewall
2) Nylon Belts	2) Steel Belts
3) Standard duty	3) Severe / Extreme duty
4) Less expensive	4) more expensive
5) Low life expectancy	5) Long life expectancy