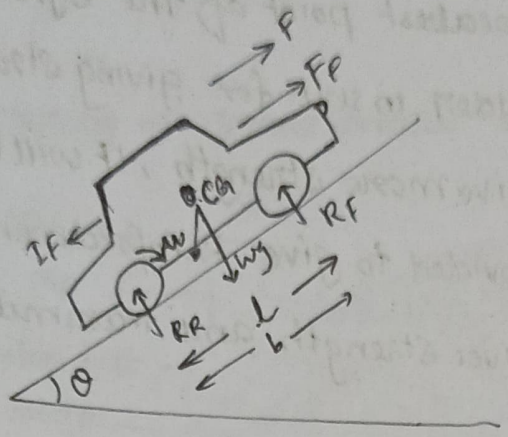
1 Q. Derive the equation of motion and maximum tractive effort for a car inclined at an angle θ. Also give the expression of maximum gradeability for a 4 wheel drive?



W = weight of the car

CG = centre of gravity

b = wheel base

F = maximum forward acceleration.

F_E = maximum tractive effort

R & F = Rear & front wheel

R_R & R_F = Total normal reaction at front and rear wheel

h = height from CG to road surface.

I_f = Inertia force $= m.F - W \sin\theta$

$= mf - mg.\sin\theta$

$= \frac{W}{g}.F - W \sin\theta$ ——— (1)

$\Sigma V = 0$ ——— (2)

$\Sigma H = 0$ ——— (3)

using ②

$$W\cos\theta = R_F + R_R \quad \text{——— ⑦}$$

using ③

$$F_f = \frac{W}{g}\cdot f + W\cdot\sin\theta$$

$$R_f = \frac{W}{g}f + \frac{W}{\mu}\sin\theta \quad \text{——— ⑨} \quad \frac{W}{\mu}\left\{\frac{f}{g} + \sin\theta\right)$$

Taking moment about μ

$$R_f \times b + \left(\frac{W}{g}f + W\sin\theta\right)h = W\cos\theta \times l$$

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

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

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

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

$$\left(\frac{f}{g} + \sin\theta\right) = \frac{\cos\theta\, l}{\left(\frac{b}{\mu} + h\right)} \quad \text{——— ⑧}$$

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

$$F = g\left[\left[\frac{\cos\theta\, l}{\left(\frac{b}{\mu} + h\right)}\right] - \sin\theta\right] \quad \text{——— ⑨}$$

$$R_F = \frac{W}{\mu} \times \frac{\cos\theta\, l}{\left(\frac{b}{\mu} + h\right)} \quad \text{——— ⑩}$$

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

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

$$= \omega \cos\theta - \frac{\omega}{\mu} \frac{\cos\theta\, l}{\left(\frac{b}{\mu} + h\right)}$$

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

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

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

Four wheel drive

$$F = R_F + F_F = \mu R_R + \mu R_f$$

$$\Sigma V = 0$$

$$W = R_F + R_R$$

$$\Sigma H = 0$$

$$(W/g) F = \mu R_R + \mu R_F$$

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

$$(f/g) = \mu$$

$$\Sigma V = 0$$

$$W = R_R + R_F$$

$$\Sigma H = 0$$

$$(W/g) F = \mu R_R + \mu R_F$$

Assuming slip to occured at front wheels.

First $R_F < R_R$ than

$\Sigma M_R = 0$ $\quad \rho M R_f = (w/g) F$

$$R_F b + (w/g) F_h = W_1$$