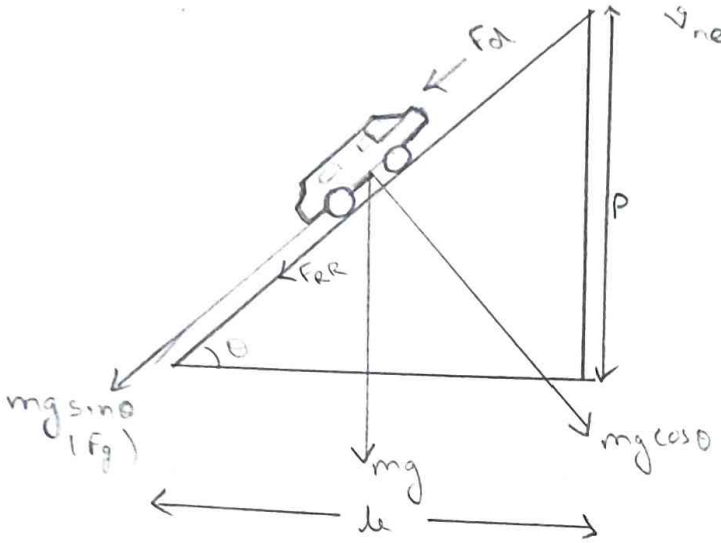
Assignment – 2

Q1 Derive the equation of motion and max-tractile effort for a car ~~vehicle~~ inclined at an $\angle\theta$

Ans.



$$V_{rel} = V_{vehicle} - (-V_{air})$$
$$= V_{vehicle} + V_{air}$$

The car is climbing an inclination of an $\angle\theta$. The following forces will be acting on the car

1) Force due to acceleration (F_a)

$$f_a = ma = \frac{m V_{rel}}{t}$$

2) Force due to aerodynamic drag (F_d)

$$F_d = \frac{1}{2} \times \rho_{air} \times C_d \times A \times V_{rel}^2$$

here, $\rho_{air} = 1.23, kg/m^3$ = density of air

C_d = Drag Coefficient

A = Frontal area (projectional) of the vehicle

$A = (\text{width} \times \text{height})_{vehicle} \times \text{ratio}$

$\text{Ratio} = \frac{\text{Projected area}}{\text{Unshaded area}}$ (on the graph)

3) Force due to rolling resistance (F_{RR})

$$F_{RR} = \mu mg\cos\theta,$$

where

$\mu \rightarrow$ Rolling Resistance coefficient (different value for different kinds of roads)

4) Climbing force or Force due to gravity (F_g)

$$F_g = mg\sin\theta$$

Now,

Tractional force (F_T) = $f_a + f_d + f_{RR} + f_g$

$$F_{trac} = \frac{mv_{rel}}{t} + \left(0.6 \times C_d \times A \times v_{rel}^2\right) + \mu mg\cos\theta + \mu mg\sin\theta$$

* Derivation of 3 Equations of motions

The three equations are

(a) $v = u + at$

(b) $s = ut + \frac{1}{2}at^2$

(c) $v^2 = u^2 + 2as$

(a) $v = u + at$

Considering a body moving with uniform acceleration

∴ Initial acceleration $\rightarrow u$

Acceleration $\rightarrow a$

Time period $\rightarrow t$

Distance travelled $\rightarrow s$

Final velocity $\rightarrow v$

We know that

$a = \frac{v_f - v_i}{t}$, where $v_f \rightarrow$ final velocity
$v_i \rightarrow$ initial velocity

Here $a = \frac{v - u}{t}$

$\Rightarrow at = v - u$

$\boxed{\Rightarrow v = u + at}$ ——— (i)

(ii) $S = ut + \frac{1}{2}at^2$

We know

$v = \frac{s}{t}$ { $s \rightarrow$ displacement }

$\Rightarrow s = v \times t$

Now considering the velocity is unstable, we can use v_{avg}

$\therefore v_{avg} = \frac{v_f + v_i}{2}$

$s = \frac{v_i + v_f}{2} \times t = \frac{u + v}{2} \times t$

From eqn (i) $v = u + at$

$\therefore s = \frac{u + v}{2} \times t = \frac{u + (u + at)}{2} \times t$

$\Rightarrow s = \frac{2u + at}{2} \times t$

$\Rightarrow s = \left(\frac{2u}{2} + \frac{at}{2}\right) \times t$

$\boxed{\Rightarrow s = ut + \frac{1}{2}at^2}$ ——— (ii)

c) $v^2 = u^2 + 2as$

We know $s = v \times t$, $\Rightarrow t = \frac{s}{v}$

Eqn (i) $\rightarrow v = u + at$

$\Rightarrow t = \frac{v - u}{a}$

$$\frac{v-u}{a} = \frac{s}{v}$$

$$\Rightarrow \frac{v-u}{a} = \frac{s}{\frac{u+v}{2}} \quad \left\{ v_{avg} = \frac{u+v}{2} \right\}$$

$$\Rightarrow (v-u)(v+u) = 2as$$

$$\Rightarrow 2as = v^2 - u^2$$

$$\boxed{\Rightarrow v^2 = u^2 + 2as} \quad \text{——} \quad (iii)$$

Q Give the expression of gradeability for a 4-wheel drive.

Expressing Gradeability of a 4 wheel drive

$$\text{Gradeability} = \frac{T_{max} \times \text{S.F} \times \text{gear ratio} \times \text{Drive ratio}_{final} \times \eta_{transmission\ mech}}{F_{vehicle} \times r_{wheel}}$$

where,

S.f → safety factor

Q2 Consider a car with the following specs parked on a level road. Find the load on the front and Rear axle.

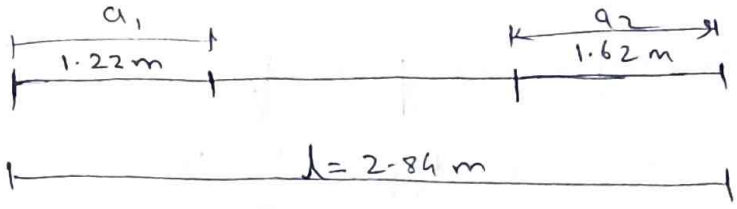
Given, $m = 1765\,kg$

l (wheel base) $= 2.84\,m$

a_1 (axle 1 length) $= 1.22\,m$

a_2 (axle 2 length) $= 1.62\,m$

Ans



Now,

$$W_r = \frac{W_{vehicle} \times C.G_f}{WB}$$

$$W_f = W_{vehicle} - W_r$$

Where,

$W_r \rightarrow$ load on rear axle

$CG_f \rightarrow$ dist from C.G to front axle

$WB \rightarrow$ wheel base

$W_f \rightarrow$ load in front axle

$\therefore W_{vehicle} = mg$

$= (1765 \times 9.81)$ kg m/s^2

$= 17314.65$ kg m/s^2

$= 17.3$ kN

$C.G_f = a_1 + (l - a_2)$

$= 1.22 + (2.84 - 1.62)$

$= 2.44$ m

$WB\ (l) = 2.84$ m

$\therefore W_r = \frac{W_{vehicle} \times C.G_f}{WB}$

$\Rightarrow W_r = \frac{17314.65 \times 2.44}{2.84} = 14.9$ kN

$\therefore W_f = W_{vehicle} - W_r$

$\Rightarrow W_f = (17.3 - 14.9)$ kN

$\Rightarrow W_f = 2.4$ kN

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Q3 What are the different parts of tires? Differentiate between types of tyres on the basis of their construction.

Tyre Construction & Specification

Let us consider a tyre eg:-

260/60	R	17	96 H
Thread width	sidewall	Radial Tyre	rimsize (Tyre diameter)

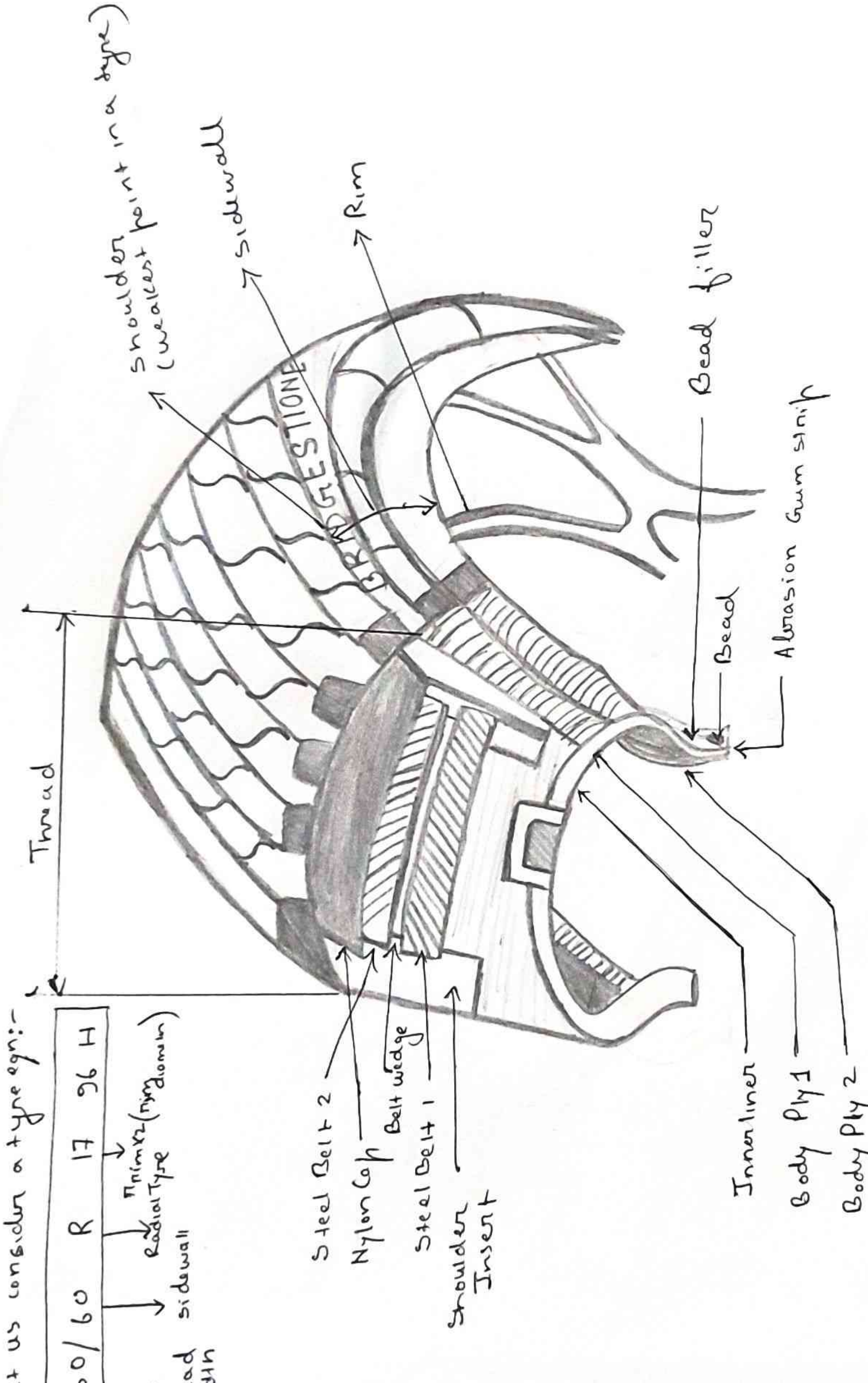

Fig:- Tyre Construction.

Ans Tyres on the basis of their construction :—
a) Radial (ii) Bias tyres.

Radial Tyres	Bias tyres
1) They are also called tubeless tyres.	1) They are also called tube tyres.
2) Network of chords running through the tyre parallel to each other and along the tyre circumference.	2) Network of clouds are placed at an angle of 30° to 40° to each other.