Assignment - 1

Q.1 Given,

$C_d = 0.51$, $A \rightarrow 0.72\ m^2$, $v_{max} = 130\ km\,h^{-1}$

$= 130 \times \frac{5}{18}\ ms^{-1}$

$\approx 36\ ms^{-1}$

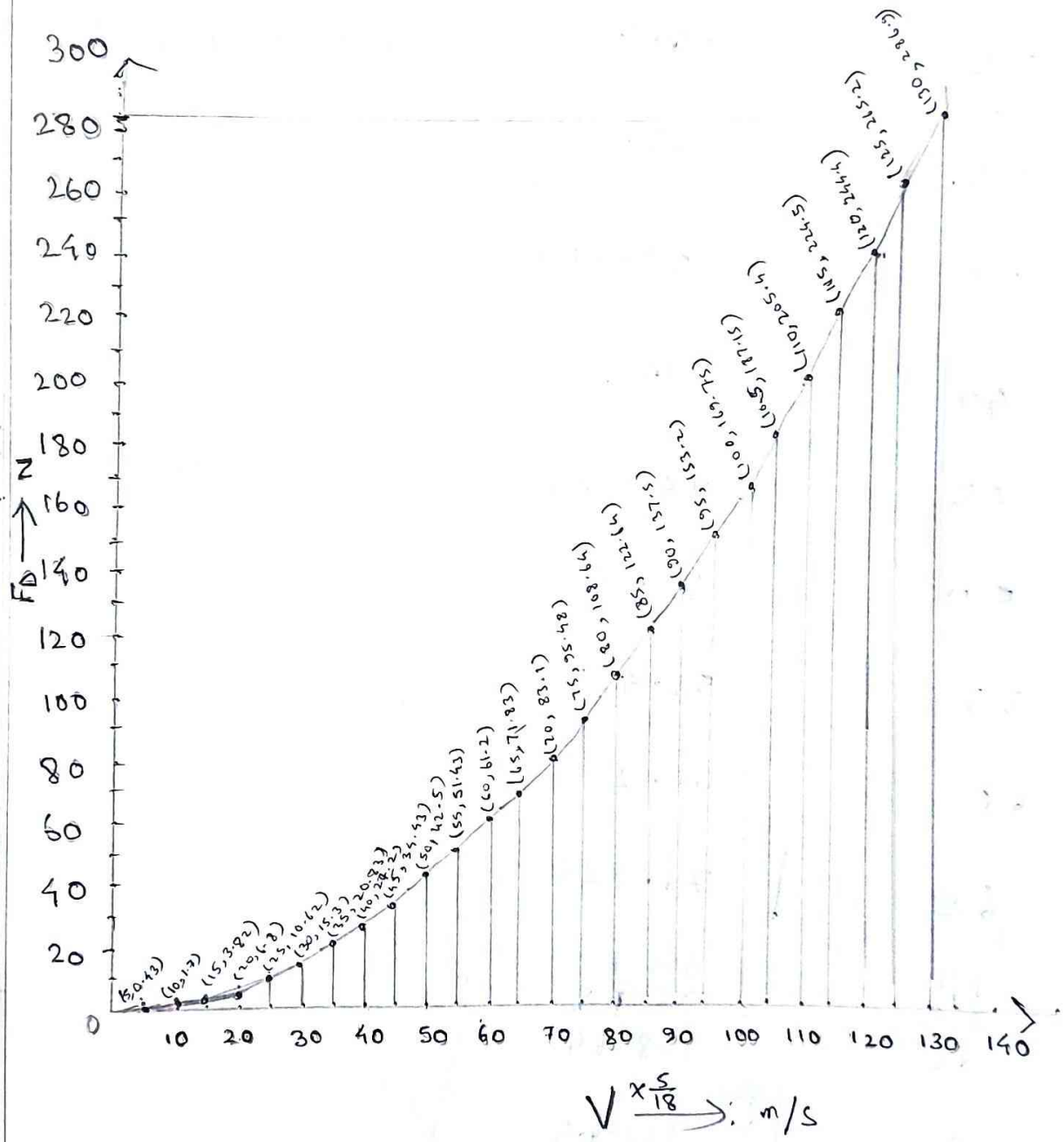
To calculate air resistance of the vehicle for the speed from (0 - 130) $km\,h^{-1}$ (The max. speed increment of 5 $km\,h^{-1}$).
Also, plot the graph of aerodynamic force vs the speed.

Sol^n: Air resistance = aerodynamic force,

$$f_D = 0.6 \times C_d \times A \times v^2$$

Sl. No.	Speed (ms^{-1})	Fd (N)
1	$5 \times 5/18$	0.425
2	$10 \times 5/18$	1.7
3	$15 \times 5/18$	3.825
4	$20 \times 5/18$	6.8
5	$25 \times 5/18$	10.625
6	$30 \times 5/18$	15.3
7	$35 \times 5/18$	20.825
8	$40 \times 5/18$	27.2
9	$45 \times 5/18$	34.425

Sl No	Speed (m s^{-1})	Fa (N)	Pg
10	50 × 5/18	42.3	
11	55 × 5/18	51.42	
12	60 × 5/18	61.2	
13	65 × 5/18	71.825	
14	70 × 5/18	83.1	
15	75 × 5/18	95.48	
16	80 × 5/18	108.64	
17	85 × 5/18	122.64	
18	90 × 5/18	137.5	
19	95 × 5/18	153.2	
20	100 × 5/18	169.75	
21	105 × 5/18	187.15	
22	110 × 5/18	205.4	
23	115 × 5/18	224.5	
24	120 × 5/18	244.4	
25	125 × 5/18	265.2	
26	130 × 5/18	286.9	


300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
Fd → N
10 20 30 40 50 60 70 80 90 100 110 120 130 140
V x 5/18 → m/s
(5, 0.43)
(10, 1.7)
(15, 3.82)
(20, 6.8)
(25, 10.62)
(30, 15.3)
(35, 20.83)
(40, 27.22)
(45, 34.43)
(50, 42.5)
(55, 51.43)
(60, 61.2)
(65, 71.83)
(70, 83.1)
(75, 95.48)
(80, 108.96)
(85, 123.4)
(90, 137.5)
(95, 153.2)
(100, 169.75)
(105, 187.15)
(110, 205.4)
(115, 224.5)
(120, 244.4)
(125, 265.2)
(130, 286.8)

Q.2 For the following determine the drag resistance of at the speed of 40 km/hr

(1) Nissan leaf (2) Tesla Model S Plaid

(3) Tata Nexon (4) Toyota Prius

(5) Ather 450 x (6) Royal Enfield

Ans:- We know,

$$F_d = 0.6 \times C_d \times A \times v^2$$

(1) Nissan leaf

$C_d = 0.28$ (2013 model), $A \rightarrow 2.27\ m^2$

$v = 40\ km/h = 40 \times \frac{5}{18}\ m/s = 11.11\ m/s$

$\therefore F_D = 0.6 \times 0.28 \times 2.27 \times (11.11)^2$

$\approx 47\ N$

(2) Tesla Model S Plaid [PS 2012 model]

$C_d = 0.24$, $A = 2.34\ m^2$

$\therefore F_D = 0.6 \times 0.24 \times 2.34 \times (11.11)^2$

$\approx 42\ N$.

(3) Tata Nexon.

C_d = [illegible], [illegible] $C_d = 0.18$, $A = 2.472\ m^2$

$\therefore F_d = 0.6 \times 0.18 \times 2.472 \times (11.11)^2$

$\approx 33\ N$

(4) Hyundai Prime.

$C_d = 0.25$, $A = 2.17\ m^2$

$\therefore F_d = 0.6 \times 0.25 \times 2.17 \times (11.11)^2$

$\approx 40\ N$.

(5) Ather 450 X

$C_d = 0.9$, $A = 0.7\ m^2$

$\therefore F_d = 0.6 \times 0.9 \times 0.7 \times (11.11)^2$

$\approx 47\ N$.

(6) Royal Enfield

$C_d = 0.95$, $A = 0.9\ m^2$.

$\therefore F_d = 0.6 \times 0.95 \times 0.9 \times (11.11)^2$

$\approx$ [illegible] $33.3\ N$.

① Nissan leaf

$v_f = 100 \text{ km/h}$

$= 100/3.6 \text{ ms}^{-1} \approx 28 \text{ ms}^{-1}$

$t = 7.9 \text{ s}$

$r_{wheel} = 8 \text{ inches} = 0.2032 \text{ m}$, $m = 1595 \text{ kg}$

$P_{peak} = \frac{m v_f^2}{t} = \frac{1595 \times (28)^2}{7.9} = 158.2 \text{ kW}$

$\tau = \frac{m v_f}{t} \times r_{wheel}$

$= \frac{1595 \times 28}{7.9} \times 0.2032$

$= 1148.72 \text{ Nm}$

② Tesla Model S Plaid.

$v_f = 100 \text{ km h}^{-1} \approx 28 \text{ ms}^{-1}$, $t = 1.99 \text{ s}$.

$r_{wheel} = 9.5 \text{ inches} = 0.2413 \text{ m}$

$m = 2162 \text{ kg}$

$\therefore P_{peak} = \frac{2162 \times (28)^2}{1.99} = 851.76 \text{ kW}$

$\tau = \frac{m v_f}{t} \times r_{wheel}$

$= \frac{2162 \times 28}{1.99} \times 0.2413$

$= 7340.3 \text{ Nm}$

(3) Tata Nexon EV

$v_f = 100$ kmph, $t = 9.3$ s

$m = 1400$ kg

$r_{wheel} = 8$ inches ≈ 0.2032

$v_f \approx 28\ ms^{-1}$

$\therefore P_{peak} = \frac{m v_f^2}{t}$

$= \frac{1400 \times (28)^2}{9.3}$

≈ 118 KW

$\tau = \frac{m v_f}{t} \times r_{wheel}$

$= \frac{1400 \times 28}{9.3} \times 0.2032$

$= 856.5$ Nm

(4) MG ZS EV

$v_f = 100\ kmh^{-1} \approx 28\ ms^{-1}$, $t = 8.2$ s

$r_{wheel} = 8.5$ inches $= 0.2159$ m

$m = 1539$ kg

$P_{peak} = 1539 \times (28)^2 / 8.2$

$= 147$ kW

$\tau = \frac{1539 \times 28}{8.2} \times 0.2159$

$= 1134.5$ Nm

5.) Hyundai Kona.

$v_f = 100 \text{ km/h} \approx 28 \text{ ms}^{-1}$, $t = 6.6 \text{ s}$

$r_{wheel} = 8.5 \text{ inches} = 0.2159 \text{ m}$

$m = 1685 \text{ kg}$.

$\therefore P_{peak} = \frac{m v_f^2}{t} = \frac{1685 \times (28)^2}{6.6} \approx 200 \text{ kW}$

$\tau = \frac{m v_f}{t} \times r_{wheel} = \frac{1685 \times 28}{6.6} \times 0.2159$

$\approx 1543 \text{ Nm}$.

6.) ~~Ather~~ 450 X

$v_f = 40 \text{ km/h} = 11.11 \text{ ms}^{-1}$, $t = 3.9 \text{ s}$

$r_{wheel} = 0.1524 \text{ m}$.

$m = 108 \text{ kg}$

$\therefore P_{peak} = \frac{108 \times (11.11)^2}{3.9} = 3.411 \text{ kW}$

$\tau = \frac{108 \times 11.11 \times 0.1524}{3.9} \approx 47 \text{ Nm}$

7) Royal Enfield (Classic 350)

$v_f = 60 \text{ km/h} \approx 16.7 \text{ ms}^{-1}$, $t = 4.2 \text{ s}$

$r_{wheel} = 9.25 \text{ inch} = 0.235$, $m = 375 \text{ kg}$

$\therefore P_{peak} = 375 \times (16.7)^2 / 4.2 \approx 25 \text{ kW}$

$\tau = \frac{375 \times 16.7 \times 0.235}{4.2}$

$\approx 350 \text{ Nm}$.

11th March, Fri, 2022

(8) Bajaj Dominar (400)

v_f = 100 km/h , t = 8.4 s

≈ 28 ms^{-1}

r_{wheel} = 8.5" inches = 0.2159 m

m = 193 kg

$P_{peak} = 193 \times (28)^2 / 8.4 = 18$ kW, $\tau = \frac{193 \times 28}{8.4} \times 0.2159$

≈ 139 Nm.

(9) Hero Splendor

v_f = 60 km/h ≈ 17 ms^{-1}, t = 8 s

m = 112 kg , r_{wheel} = 8 inches = 0.2032 m

$P_{peak} = \frac{112 \times (17)^2}{8} \approx 4$ kW.

$\tau = \frac{112 \times 17 \times 0.2032}{8} \approx 48$ Nm.

Assignment

Q. 4. To plot the graph of F_{trac}, F_a, Rolling resist. against V_f.

Ans: ① F_{trac} for Nissan Leaf

$F_{trac} = \frac{m v_f}{t} + mg\mu\cos\theta + mg\sin\theta + (0.6 \times \rho \times A \times v_f^2)$

* $\frac{m v_f}{t} = \frac{1595 \times 28}{7.9} = F_a = 5.6$ kN.

* $mg\mu\cos\theta = mg\mu = 1595 \times 9.8 \times 0.013$ [considering concrete road]

[$\cos\theta = 1$]

=) Rolling resist. = 0.2 kN

∵ Since there is no inclination, $mg\sin\theta$ for every case will be 0

$f_d = 0.6 \times C_d \times A \times V_f^2$ = ~~0.047 kN~~, f_{trac} = ~~5.8 kN~~.

$= 0.6 \times 0.28 \times 2.27 \times (28)^2 = 0.3$ kN

② Tesla Model S Plaid $f_{trac} = 6.1$ kN.

$f_a = \frac{mv_f}{t} = \frac{2162 \times 28}{1.99} = 30.42$ kN.

Rolling resist $= 2162 \times 9.80 \times 0.013$

$= 0.3$ kN

$f_d = 0.6 \times C_d \times A \times V_f^2 = 0.26$ kN.

$f_{trac} = 31$ kN.

③ Tata Nexon EV

$f_a = \frac{mv_f}{t} = \frac{1400 \times 28}{9.3} = 4.2$ kN

Rolling resist. $= 1400 \times 9.8 \times 0.013 = 0.17$ kN

$f_d = 0.6 \times C_d \times A \times (28)^2 = 0.20$ kN

$f_{trac} = 4.57$ kN.

(4) MG ZS EV

$$f_a = \frac{mv_f}{t} = \frac{1539 \times 28}{8.2} = 5.25 \text{ kN}$$

Rolling resist. $= 1539 \times 9.8 \times 0.013 = 0.2$ kN

$$f_d = 0.6 \times C_d \times A \times v_f^2 = 0.6 \times 0.28 \times 2.472 \times (28)^2$$
$$= 0.32 \text{ kN}$$

$$F_{trac} = 5.25 + 0.2 + 0.32 = 5.8 \text{ kN}$$

(5). Hyundai Kona

$$f_a = \frac{mv_f}{t} = \frac{1685 \times 28}{6.6} = 7.14 \text{ kN}$$

Rolling resist. $= 1685 \times 9.8 \times 0.013 = 0.21$ kN.

$$f_d = 0.6 \times C_d \times A \times v_f^2 = 0.6 \times 0.28 \times 2.472 \times (28)^2$$
$$= 0.3 \text{ kN}$$

$$F_{trac} = 7.65 \text{ kN}.$$

(6) Ather 450X

$f_a = \frac{m v_f}{t} = \frac{108 \times 11.11}{3.9} = 0.3$ kN

Rolling resist = $108 \times 9.8 \times 0.013 = 0.01$ kN

$f_d = 0.6 \times C_d \times A \times v_f^2 = 0.6 \times 0.9 \times 0.7 \times (11.11)^2$

$= 0.04$ kN

$f_{trac} = 0.35$ kN

(7) Royal Enfield

$f_a = \frac{m v_f}{t} = \frac{375 \times 16.66}{4.2} = 1.5$ kN

Rolling resist = $375 \times 9.8 \times 0.013 = 0.05$ kN

$f_d = 0.6 \times C_d \times A \times (16.66)^2 = 0.6 \times 0.5 \times 0.9 \times (16.66)^2$

$= 0.07$ kN

$f_{trac} = 1.62$ kN

(8) Bajaj Dominar

$f_a = \frac{m v_f}{t} = 193 \times 28 / 8.4 = 0.64$ kN

Rolling resist = $193 \times 9.8 \times 0.013 = 0.03$ kN

$f_d = 0.6 \times C_d \times A \times (28)^2 = 0.6 \times 0.5 \times 0.8 \times (28)^2$

$= 0.2$ kN

$f_{trac} = 0.87$ kN

(9) Hero Splendor

$$f_a = \frac{m v_f}{t} = \frac{112 \times 16.66}{8} = 0.23 \text{ kN}$$

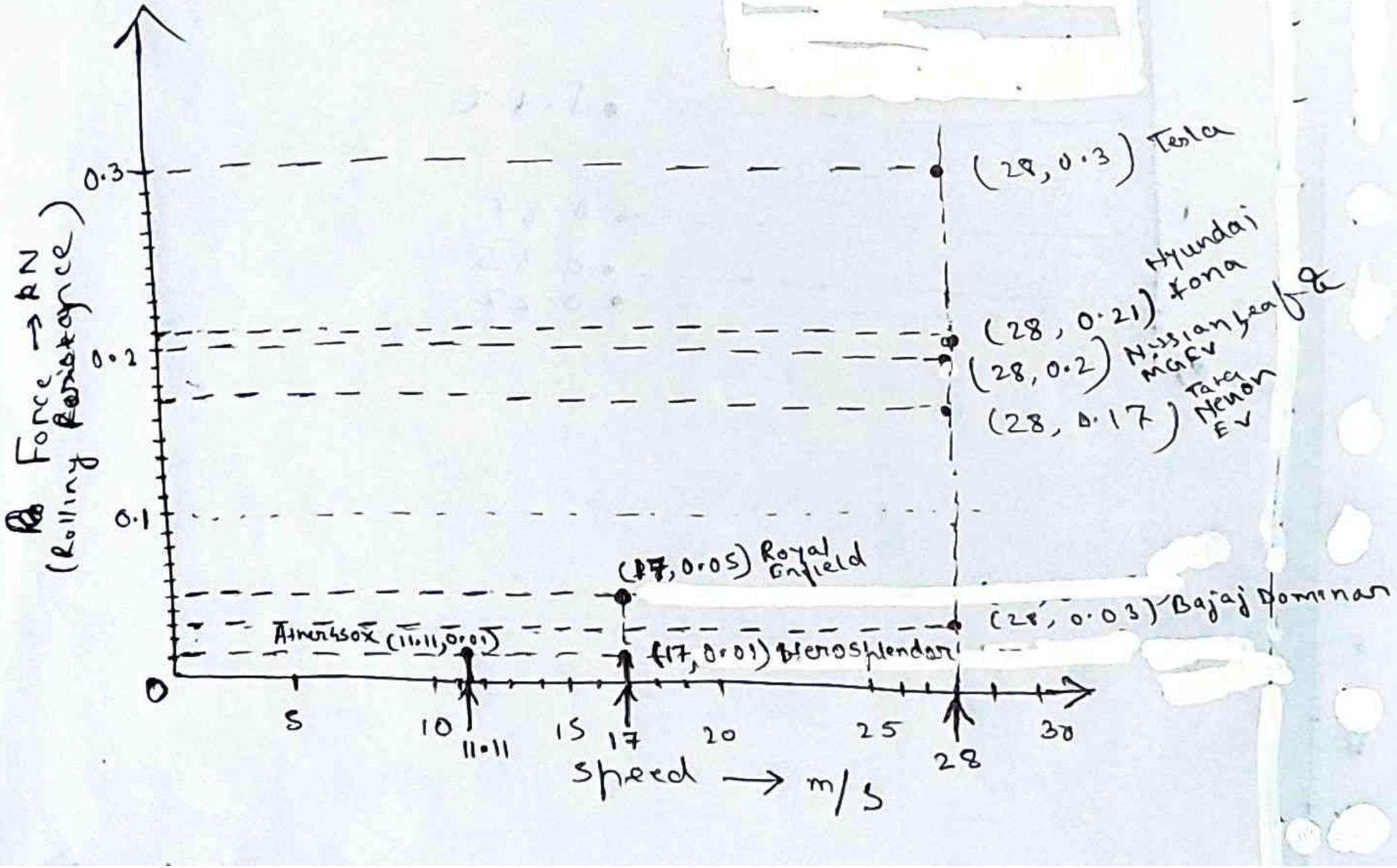
Rolling resist = $112 \times 9.8 \times 0.013 = 0.01 \text{ kN}$

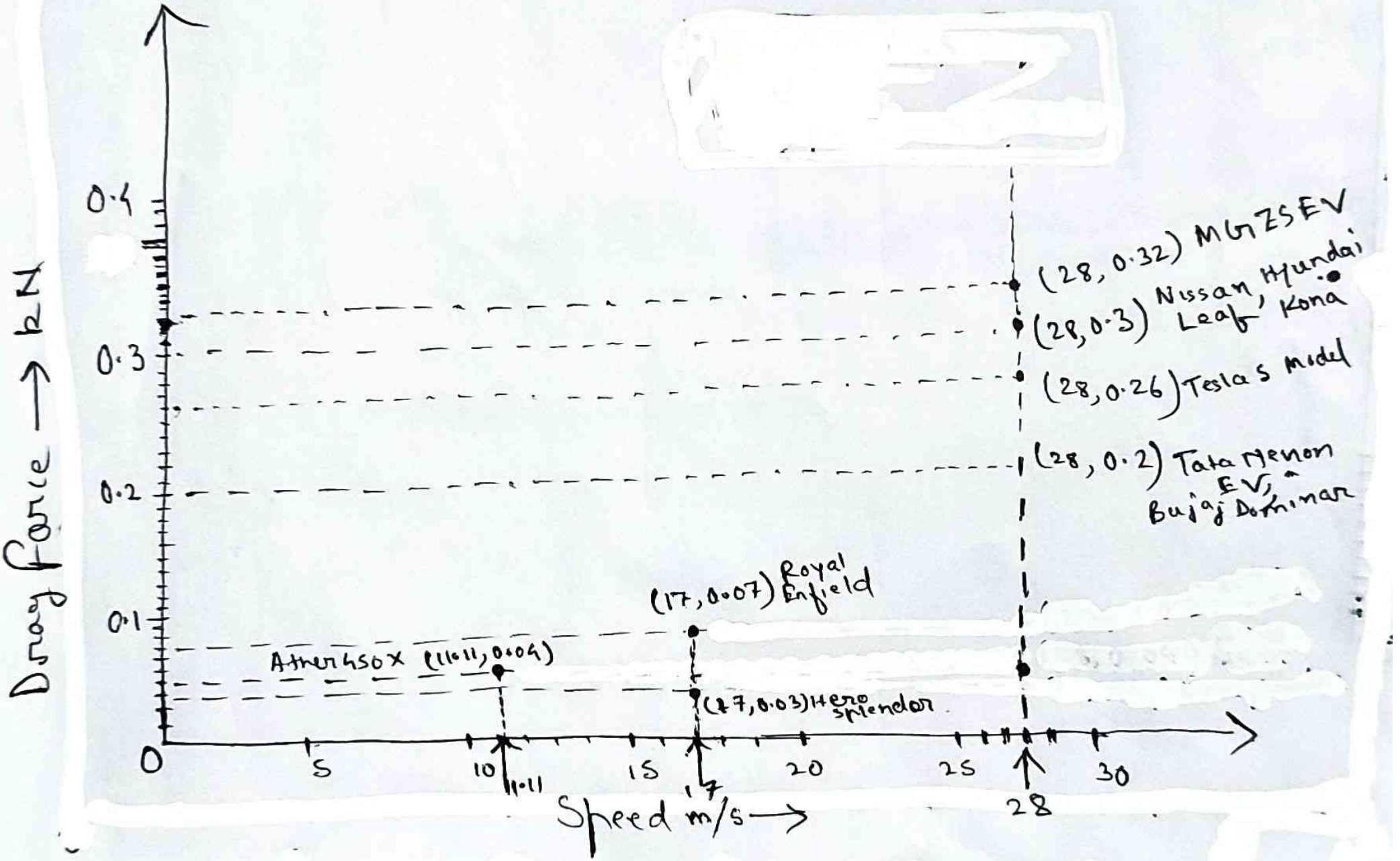
$$f_a = 0.6 \times A \times C_a \times v_f^2$$

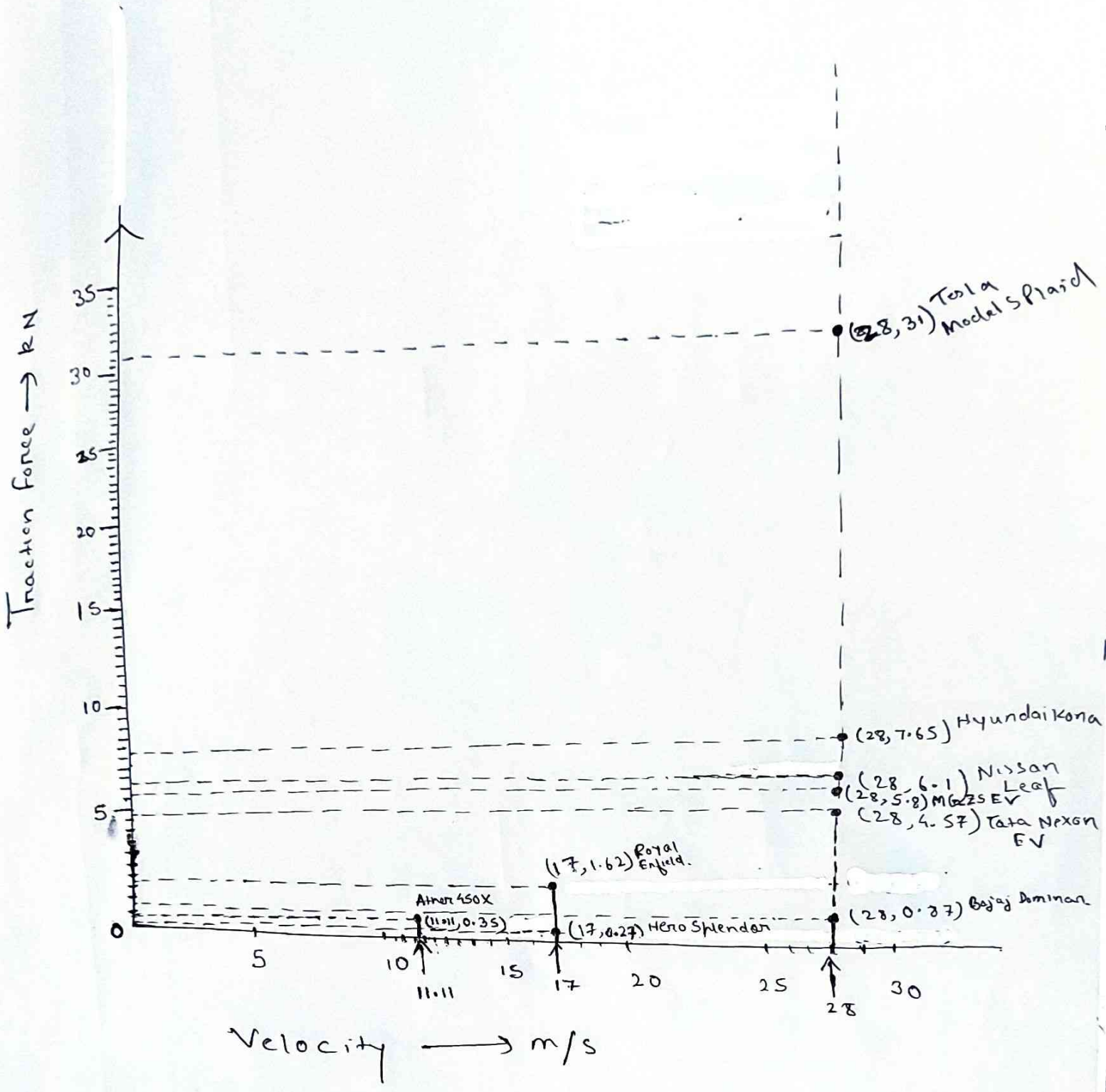
$$= 0.6 \times 0.3 \times 0.7 \times (16.66)^2$$

$$= 0.03 \text{ kN}$$

$$f_{trac} = 0.27 \text{ kN}$$


Force → RN
(Rolling Resistance)
0.3
0.2
0.1
0
(28, 0.3) Tesla
(28, 0.21) Hyundai Kona
(28, 0.2) Nissan Leaf & MG EV
(28, 0.17) Tata Nexon EV
(17, 0.05) Royal Enfield
(28, 0.03) Bajaj Pulsar
Ather 450X (11.11, 0.01)
(17, 0.01) Hero Splendor
5
10
11.11
15
17
20
25
28
30
Speed → m/s


Drag force → kN
0.4
0.3
0.2
0.1
0
5
10
11.11
15
17
20
25
28
30
Speed m/s →
(28, 0.32) MG ZS EV
(28, 0.3) Nissan, Hyundai Leaf, Kona
(28, 0.26) Tesla S model
(28, 0.2) Tata Nexon EV, Bajaj Dominar
(17, 0.007) Royal Enfield
Ather 450X (11.11, 0.04)
(17, 0.03) Hero Splendor


Traction force → kN
35
30
25
20
15
10
5
0
(28, 31) Tesla Model S Plaid
(28, 7.65) Hyundai Kona
(28, 6.1) Nissan Leaf
(28, 5.8) MG ZS EV
(28, 4.57) Tata Nexon EV
(17, 1.62) Royal Enfield.
Ather 450X
(11.11, 0.35)
(17, 0.27) Hero Splendor
(28, 0.87) Bajaj Aminan
5
10
15
17
20
25
28
30
11.11
Velocity → m/s