

$$F_r = \mu_{rr} \omega$$

$$F_a = m a$$



$$F_r = \mu_{rr} \omega = \mu_{rr} \times m g$$

$$F_a = m a =$$

→ Total Tractive Effort : $TTE = f_a + f_{rr}$

$$TTE_{\text{per axle}} = \frac{TTE}{n_{\text{motors}}} = \frac{TTE}{2}$$

$$T_{req} = TTE_{\text{per motor}} \times r_{\text{wheel}} \times R_f$$

(R_f is resistance factor $R_f \in [1.1, 1.15]$)

$$\rightarrow T_{req} = m \frac{0.1 + 0.81 \times 0.58}{2} \times 0.0508 \times 1.12 = \boxed{0.1647 \text{ N}}, \quad T = T_{\text{motor}} \times \text{reduction ratio (i)}$$

drag stage reduction

- Nema 17 (0.7 N.m model) : $T = 6.3 \text{ N.m}$, $m = 38.25 \text{ kg}$, $v_{max} = 0.174 \text{ m/s}$
- Nema 23 (1.2 N.m model) : $T = 10.8$, $m = 65.57 \text{ kg}$, $v_{max} = 0.58 \text{ m/s}$
- Nema 23 (2.2 N.m model) : $T = 18.8 \text{ N.m}$, $m = 120.24 \text{ kg}$, $v_{max} = 0.872 \text{ m/s}$

propulsion stage reduction

- Nema 23 (1.2 N.m) : $T = 32.4 \text{ N.m}$, $m = 186.7 \text{ kg}$, $v_{max} = 0.183 \text{ m/s}$
- Nema 23 (2.2 N.m) : $T = 58.4 \text{ N.m}$, $m = 360.6 \text{ kg}$, $v_{max} = 0.28 \text{ m/s}$