Wheels Section

Many factors affect the choice of wheels – rolling resistance is affected by the materials of the wheels and bearings, with the ability to transfer power dependent on the radii and material of the driven wheels.

Commercial longboard wheels are typically made from polyurethane, with construction normally consisting of a hardened plastic core with the outer layers and surface of polyurethane. This material achieves a $\mu_{rolling}$ in the range of 0.04-0.08 – while this is sufficiently small to provide low rolling resistance, polyurethane also only provides a μ_{static} of ~0.2, limiting the amount of torque than can be transferred from the motor to road surface. This can be ameliorated by using rubber for the driven wheels as rubber achieves a μ_{static} in the range of 0.35-0.45, allowing for an increase in torque transmitted of 75-125%.

Bearing materials for longboard wheels come in three different material families: steel, titanium and ceramic. Whilst exact values of frictional resistance are difficult to find, comparisons can be extrapolated from their material properties. Ceramic (Silicon Nitride) has a Brinell hardness 1479 kg/mm^2, an increase of approx. 640% over that of AISI 52100 steel and ASTM 7 Titanium[1]. This would suggest much less energy lost from elastic deformation. However, Silicon Nitride also exhibits a yield strength of 170MPa: approx. 64% less than steel and titanium. As such ceramic may be unadvisable as the board will be used in an environment not dedicated to skateboarding and is likely to suffer various shocks. Additionally, ceramic bearings cost significantly more than steel and titanium, the former often in the $90-$150 range, as opposed to $15-$20 and $30 mark for steel and titanium respectively. Due to the similar properties of steel and titanium bearings, the latter's corrosion resistance may suggest that it is the optimal of the three, increasing savings in the long-run by requiring less maintenance.

Longboard wheels typically vary in diameter between 60-100mm with a contact patch width of ≈30mm – the size of wheel can be selected to provide the required torque at ground, with the relevant calculations shown below.

Tables and Calculations

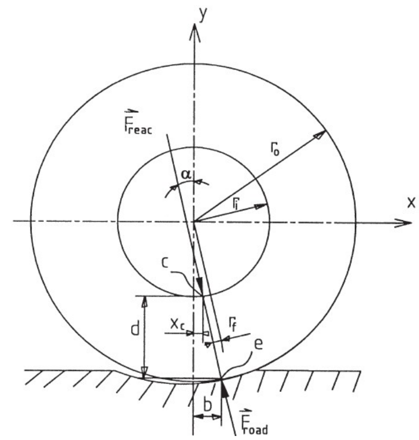
Material	**μ-static**	**μ-dynamic**
Polyurethane	~ 0.2	0.04-0.08
Rubber	0.35-0.45	0.01-0.015

$T_g = Torque\ at\ Ground$ $\qquad$ $T_w = Torque\ at\ Wheel$ $\qquad$ $r = wheel\ radius$

$$T_g = \frac{T_w}{r}$$

[1] These specific materials are the three most commonly used in the bearings of each material type.

<u>Resistances at Wheels</u>



Total mass ≈ 150kg

Mass per wheel = 37.5kg

F_{RES} = Resistive force from Wheels

F_{load} = 37.5kg x 9.81 = 367.9N (per wheel)

$\mu_{static\text{-}rubber} = 0.015$ $\mu_{static\text{-}polyurethane} = 0.08$

$\mu_{bearing} = 0.0015$ (assumed upper bound)

$\mu_{rolling\text{-}rubber} = 0.45$ $\mu_{rolling\text{-}polyurethae} = 0.2$

$r_i = 11mm$ $r_o = 35mm$

$F_{RES} = (\mu_{static} - r_i\sin(\alpha)\cos(\arcsin(r_f/r_i)) + r_f\cos(\alpha))$ x $(F_{load}/(r_o - r_i))$

$\alpha = \arctan(F_p/F_{load})$

$(r_f/r_i) = \mu_{bearing}$

$\arcsin(r_f/r_i) = 0.0859° \rightarrow \cos(\arcsin(r_f/r_i) \approx 1$

Static (Skateboard Stationary, Wheels not Moving):

$F_{RES\text{-}rubber} \approx 4.9037$ $F_{RES\text{-}polyurethane} \approx 2.2757$

$F_{RES\text{-}Total\text{-}Static} = 2\ F_{RES\text{-}rubber} + 2\ F_{RES\text{-}polyurethane} = 14.36N$

Dynamic

$F_{RES\text{-}rubber} \approx 0.33111$ $F_{RES\text{-}polyurethane} \approx 1.0144$

$F_{RES\text{-}Total\text{-}Dynamic} = 2\ F_{RES\text{-}rubber} + 2\ F_{RES\text{-}polyurethane} = 2.691N$