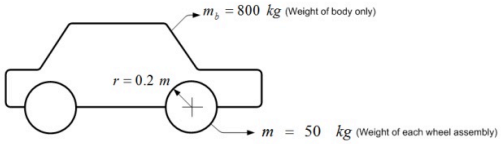
Ex 1) In-Wheel Motor Example

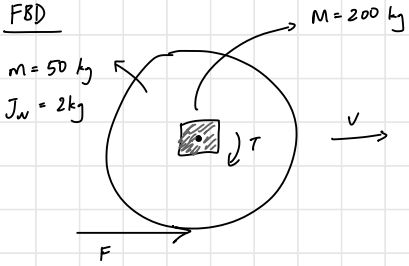
- **Determine the torque/speed of a motor to**
  - **accelerate from 0 to 100 km/h in 6 seconds**
  - **the maximum speed of 200 km/h.**



- **For the selected motor, find the average power during 0 to 100 km/h acceleration**

Assume:
- Body mass is distributed to each axle equally
- Wheel mass is distributed uniformly over wheel area

FBD



Rotational inertia:

$$J_w = \frac{mr^2}{2} = \frac{50 \times 0.2^2}{2} = 1\ kg\ m^2$$

Required speed:

$$V = 200\ km/h \times \frac{1000\ m/km}{3600\ s/h} = 55.56\ m/s$$

$$w = \frac{V}{r} = \frac{55.56}{0.2}\ rad/s \times \frac{60\ s/min}{2\pi\ rad/rot.} = 2653\ rpm$$

Required acceleration:

$$100\ km/h \times \frac{1000}{3600} = 27.8\ m/s$$

$$a = \frac{27.8\ m/s}{6s} = 4.63\ m/s^2$$

$$\alpha = \frac{a}{r} = \frac{4.63}{0.2} = 23.15\ rad/s^2$$

Required torque:

Rotational: $J_w \alpha = T - Fr$ (F is frictional force from rolling under static friction)

Linear: $(M+m)\,a = F$

$$\Rightarrow J_w \alpha = T - (M+m)\,a \cdot r$$

$$T = J_w \alpha + (M+m)\,ar \cdot r$$

$$T = (J_w + (M+m)r^2)\,\alpha = (1 + (200+50)\,0.2^2)\,23.15 = \boxed{254.65\ N/m}$$

Average power: $P_{av} = \frac{KE}{T}$ — Kinetic energy

$\omega = \frac{v}{r}$

For 100 km/h, $KE = \frac{1}{2} J_w \omega^2 + \frac{1}{2}(M+m)v^2$

$$= \frac{1}{2}\left(\frac{v}{r}\right)^2 \left(J_w + (M+m)r^2\right)$$

$$= \frac{1}{2}\left(\frac{100 \times \frac{1}{3.6}}{0.2}\right)^2 \left(1 + 250 \times 0.2^2\right) = \boxed{106.1 \text{ kJ}}$$

$$\therefore P_{av} = \frac{106.1 \times 10^3}{6} = \boxed{17.68 \text{ kN}}$$

Max power at 200 km/h:

$$P_{max} = T_{max} \times \omega_{max} = 254.65 \times 265\tilde{3} \times \frac{2\pi}{60}$$

$$= \boxed{70.75 \text{ kW}}$$