

RBE 595 — FAIR-AV
Week 6 Homework #1

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Problem 1

Let's define the time to accelerate a vehicle from 0 speed to 100 km/h as τ_{100} , which is constantly used by battery-electric car (BEV) manufacturers to brag about their technological advancement. Provide the formulas to compute the minimal τ_{100} for

- (a) a four-wheel drive car (with an electric motor installed at each of the axles)
- (b) a front-wheel drive (with an electric motor installed at the front axle)
- (c) rear-wheel drive (with an electric motor installed at the rear axle)

Solution

The minimum time to accelerate a vehicle from 0 speed to 100 km/h can be found using the definite integral of the maximum acceleration that the vehicle can achieve. This would be given by the velocity-time relationship for the vehicle, which in this case would be

$$100 \text{ km/h} = \int_0^{\tau_{100}} a(t) dt \quad (1)$$

assuming that the vehicle starts from rest. The maximum acceleration that the vehicle can achieve is dependent on the configuration of the vehicle, as well as the road gradient.

Four-Wheel Drive

As per the lecture slides, the maximum acceleration that a vehicle can achieve in 4WD configuration is given by

$$a_{\max} = g (\mu \cos(\alpha) - \sin(\alpha)) \quad (2)$$

where g is the acceleration due to gravity, μ is the coefficient of friction, and α is the road gradient. Substituting this into the integral in equation (1), we get

$$100 = \int_0^{\tau_{100}} g (\mu \cos(\alpha) - \sin(\alpha)) dt \quad (3)$$

Since everything in the integrand is constant, we can pull it out of the integral to get

$$100 = g (\mu \cos(\alpha) - \sin(\alpha)) \int_0^{\tau_{100}} dt \quad (4)$$

Therefore, the minimum time to accelerate a 4WD vehicle from 0 speed to 100 km/h is

$$\tau_{100} = \frac{100}{g (\mu \cos(\alpha) - \sin(\alpha))} \quad (5)$$

Front-Wheel Drive

The maximum acceleration that a vehicle can achieve in front-wheel drive configuration is given by

$$a_{\max} = g \left(\frac{\mu}{1 + \mu \frac{h}{a_1 + a_2}} \frac{a_2}{a_1 + a_2} \right) \quad (6)$$