**ECE 398GG** Prof. George Gross
Spring 2023

# Homework 2 on Prof. Krein's Lecture on *EV* Design & Operation

## Date due: Friday, February 10, 2023

In the solution of problems 1 – 4, ignore battery losses with the implication that those losses are considered to be part of the grid losses. A more thorough approach is to explicitly assume a battery round-trip efficiency in the 85 – 95 *%* range to get a more concrete idea. But, for the purposes of this course, that level of detail is not required.

**1.** Consider the *Nissan Leaf EV* we have been exploring in Lecture 3 with the following technical data: $C_d$ = 0.28; $A_f$ = 2.28 $m^2$; 40-*kWh* battery pack; final drive ratio 8.193:1; motor with a continuous rating of 110 kW (3,283 to 9,795 *r.p.m.*); and, a torque rating of 320 *N-m* (0 to 3,283 *r.p.m.*). You may assume a 90-*%* drivetrain efficiency and 1-*kW* hotel load in your analysis.

a. **Estimate** and compare range based on loaded masses of 1,800 *kg*, 1900 *kg* and 2000 *kg*, respectively, at 70 *mph* continuous cruise. **Compare** these three estimates and **comment** on the impacts of mass on the vehicle range.

b. For the 2,000-*kg* mass, **estimate** the range based on continuous speeds of 60 *mph*, 70 *mph* and 80 *mph*, respectively. **Compare** these three estimates and **comment** about the impacts of speed on the vehicle range.

**2.** Some experts suggest that values such as 100-*kW* continuous rating, 200-*kW* peak, 400-*N-m* torque are excessively high for passenger car motor specifications. As an alternative, **consider** a car such as the *Nissan Leaf EV*, loaded to 2,000 kg, with a motor rated for 60-*kW* continuous, 120-*kW* peak, and 200-*N-m* torque.

a. **Estimate** the final drive ratio required to support a 30-*%* gradability for this car.

b. **Determine** the attainable acceleration at 50 *mph* with the 120-*kW* limit.

c. **Estimate** the top speed under the assumption of no limit on motor rotational speed.

Additional Study Activities:

A. Learn about some of the *Worldwide Harmonized Light Vehicles Test Procedure* (*WLTP*) classes and meanings from the following suggested resources:

   a. http://www.transportpolicy.net/standard/international-light-duty-worldwide-harmonized-light-vehicles-test-procedure-wltp/
   b. http://unece.org/fileadmin/DAM/trans/doc/2014/wp29grpe/GRPE-68-03e.pdf
   c. http://www.wltpfacts.eu/what-is-wltp-how-will-it-work/

B. Pick a vehicle platform of particular interest to you. It can be either an existing or near-future electric vehicle, or a fuel-driven vehicle for which you will prepare an electric version. Please choose an on-road passenger, transport, or cargo vehicle rather than a "supercar," racecar, or off-road application. It need not be a passenger car, and you may analyze a bus, truck, or other road vehicle.

   a. For an *EV*, gather adequate data to model it (you may estimate the tire loss coefficient, published by tire vendors rather than vehicle vendors). This task requires the values of the drag coefficient, empty and loaded weights, frontal area, and any specifications about force, power, motor speeds, final drive ratio(s), etc.
   b. For an *ICEV*, gather data about weight, drag, frontal area, and engine-based performance. Pick an electric motor (and single-speed final drive ratio) that can provide similar torque and other performance attributes. Pick a lithium-ion pack, based on 180 *kW/kg*, that can provide about 150 *miles* of range.

The data you gather will be useful for future problems and analysis. You may refer to this data collection task as "your primary vehicle" for EV models.