ECE 398GG Electric Vehicles Prof. G. Gross

Quiz 2 Spring 2023

TIME 20 minutes

1. Consider an EV equipped with a 50-*kWh Li*-ion battery which has 100 % *s.o.c.* (state of charge). As part of the celebration of your graduation, you wish to take a road trip to Nashville, *TN* from Champaign, *IL* – an estimated 340-*mile* journey. You may assume the entire drive is on highways to Nashville. The manufacturer states that highway cruising requires the EV use 400 *wh/mi* at a constant speed of 70 *mph*.
    a. **Compute** the *C* rate of this battery?

        50 *kW*

    b. **Determine** whether the battery would be "happy" with a charge rate of *C*/2? If not, what is its highest ideal rate of charge?

        No, *Li*-ion batteries are happy with charge rates of C/3 or less. (Lecture 3a slide 34)

    c. Assume the EV consumes 100 % of its stored energy in the battery before each recharge and that each recharge station offers a charge rate of *C*/4. **Determine** the number recharges required to reach your Nashville destination.

        50,000 *Wh* / (400 *Wh/mi*) = 125 *mi* per charge

        340 *mi* / (125 *mi* per charge) = 2.72 charges; we round down to 2 charges.

d. **Compute** the duration the trip to Nashville takes.

340 mi / 70 mph = 4.86 hr; 50 kWh / 12.5 kW = 4 hr per charge. 2 charges makes 8 hours total charge time. 8 *h* + 4.86 *h* = 12.86 *h*

e. To maintain battery health, a *Li*-ion battery has a range of its *s.o.c.,* within which it operates. **State** the range of the *s.o.c.*

Li-ion batteries like to stay between 20 – 90 %, *i.e.,*(55 +/- 35) %, *s.o.c.* (Lecture 4, slide 41)

f. **Repeat** parts c. and d. under the condition that the EV operates within this range of the *s.o.c.* from the beginning of the trip.

The consumption of only 70 % of the battery's stored energy used in part e.'s range means that each charge replenishes 35 *kWh*. Thus, 35,000 *Wh* / 400 *Wh/mi* = 87.5 *mi*. Now, 340 *mi* / 87.5 mi = 3.89 charges are required, which we round down to 3 sessions. Each session lasts 3.5 *kWh* / 12.5 *kW* = 2.8 *h* per recharge and so the 3 sessions require 8.4 *h*. The total time for the trip becomes 8.4 *h* + 4.86 *h* = 13.26 *h*.

2. For the statements below, circle each correct statement. We discourage guesses and it helps if you provide a justification for each answer.

    a. EV considerations & EV Battery Management
        i. As mass increases, the range of an EV decreases exponentially.
            1. False. It decreases linearly. (HW 2, part a)
        ii. A battery's performance & chemical reaction is dependent on temperature.
            1. True (Lecture 4, slide 12)
        iii. In the *US*, 99 % of *NiCd* batteries are recycled.
            1. False (Lecture 4, slide 14)
        iv. Fuel-powered trucks are worse than electric trucks because gasoline is heavier than batteries per volume.
            1. False (Lecture 3a, slide 22)
        v. Mild parallel hybrids use small electric motors to recover braking energy
            1. True (Lecture 3a, slide 28)
        vi. A level 3 charger level is a charger that outputs at least 15 kW.
            1. False (Lecture 3b, slide 21)
        vii. In the *US*, 99 % of *Li*-Ion batteries are recycled.
            1. False (Lecture 4, slide 14)
        viii. As of 2022, one advantage that fuel tanks have over batteries is that they're generally cheaper.
            1. True (Lecture 3b, slide 3)