Fall 2025 EE 102: In-class Activity (Sep 15, 2025)

Bigger Energy: Electric Vehicles Edition

You are driving an electric vehicle (EV) on a one-hour trip from point A to point B. There are many ways you can do this trip — which one uses the least energy?

Each team is assigned a simple signal trace $x(t)$ in units of kW that represents how much battery is used up in an electric vehicle over $[0, 1]$ hour for a given scenario. Your task is to compute the total energy E (in kWh) to determine who has the biggest energy consumption and predict your rank (1 = least energy spent). Among your team, you should confirm that everyone has the same answer and come to a consensus of the rank. Then, you will be asked to announce your energy and your guess of where you stand.

Key formula (use t in hours):

$$E = \int_{-\infty}^{\infty} |x(t)|^2 \, dt.$$

Team Prompts (pick one per team)

All signals are zero outside the intervals shown.

Team 1: Flat road, stop, flat road

$$x_1(t) = \begin{cases} 12, & 0 \le t < \frac{1}{3} \\ 0, & \frac{1}{3} \le t < \frac{2}{3} \\ 12, & \frac{2}{3} \le t \le 1 \\ 0, & \text{otherwise} \end{cases}$$

Team 1: Record your results

Energy $E =$ _____ kWh Predicted rank = _____ (/8)

Team 2: Uphill, stop, downhill

$$x_2(t) = \begin{cases} 18, & 0 \le t < \frac{1}{3} \quad \text{(uphill)} \\ 0, & \frac{1}{3} \le t < \frac{2}{3} \quad \text{(stop)} \\ 6, & \frac{2}{3} \le t \le 1 \quad \text{(downhill)} \\ 0, & \text{otherwise} \end{cases}$$

Team 2: Record your results

Energy $E =$ _____ kWh Predicted rank = _____ (/8)

Team 3: Rapid cruise (less efficient) to destination

$$x_3(t) = \begin{cases} 13.5, & 0 \le t < \frac{2}{3} \\ 0, & \frac{2}{3} \le t \le 1 \\ 0, & \text{otherwise} \end{cases}$$

Team 3: Record your results

Energy $E =$ _____ kWh Predicted rank = _____ (/8)

Team 4: Dynamic speeding (ramp up, then ramp down)

Ramp up such that battery uses from 8 kW to 16 kW over the first 0.5 h, then ramp down to 8 kW over the next 0.5 h.

$$x_4(t) = \begin{cases} 8 + 16\,t, & 0 \le t < \frac{1}{2} \\ 24 - 16\,t, & \frac{1}{2} \le t \le 1 \\ 0, & \text{otherwise} \end{cases}$$

Team 4: Record your results

Energy $E =$ _____ kWh Predicted rank = _____ (/8)

Team 5: Stop-and-go traffic (three bursts)

Scenario where $x(t) = 18$ kW for three 10 min segments, with 10 min stops between.

$$x_5(t) = \begin{cases} 18, & 0 \le t < \frac{1}{6},\ \frac{1}{3} \le t < \frac{1}{2},\ \frac{2}{3} \le t < \frac{5}{6} \\ 0, & \text{else on } [0,1] \\ 0, & \text{otherwise} \end{cases}$$

Team 5: Record your results

Energy $E =$ _____ kWh Predicted rank = _____ (/8)

Team 6: Eco mode (slow and steady)

$$x_6(t) = \begin{cases} 9, & 0 \le t \le 1 \\ 0, & \text{otherwise} \end{cases}$$

Team 6: Record your results

Energy $E =$ _____ kWh Predicted rank = _____ (/8)

Team 7: Late starter, speeding later

$$x_7(t) = \begin{cases} 0, & 0 \le t < \frac{1}{2} \\ 16, & \frac{1}{2} \le t \le 1 \\ 0, & \text{otherwise} \end{cases}$$

Team 7: Record your results

Energy $E =$ _____ kWh Predicted rank = _____ (/8)

Team 8 — Two hills then cruise

$$P_8(t) = \begin{cases} 24, & 0 \le t < \frac{1}{4} \\ 6, & \frac{1}{4} \le t < \frac{1}{2} \\ 10, & \frac{1}{2} \le t \le 1 \\ 0, & \text{otherwise} \end{cases}$$

Team 8: Record your results

Energy $E =$ _____ kWh Predicted rank = _____ (/8)
