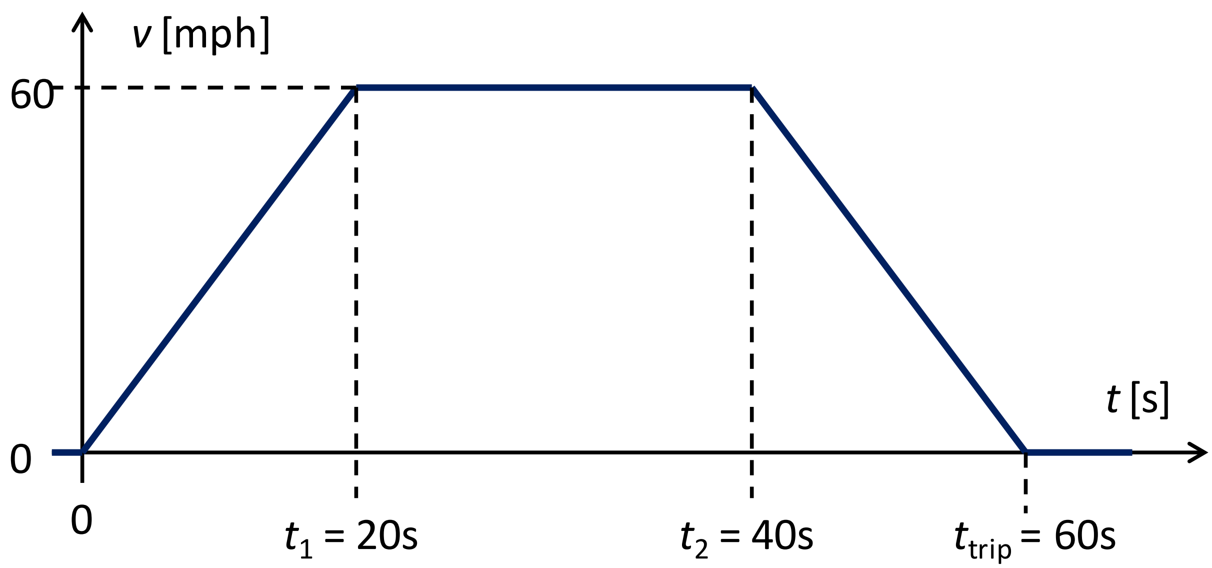
Analysis of Power and Energy over a Driving Cycle

An electric vehicle having M_v = 2000 kg, C_r = 0.015, C_d = 0.35, A_v = 2.5 m^2, is driven on a flat road over the driving cycle illustrated below. You may assume that the drivetrain is sized so that the vehicle follows the speed profile $v(t)$ perfectly. You may also assume 100% efficient drivetrain with regenerative braking capability.



For this driving cycle, do the following by analysis:

a) Plot $P_v(t)$ and label salient features.
b) Solve for an compute:
    1. Maximum tractive power P_{vmax} [kW]
    2. Maximum tractive force F_{vmax} [N]
    3. Average tractive power P_{vavg} [kW]
    4. Energy consumption in kWh per mile
    5. MPGe (miles per gallon equivalent)

Show all work. No credit will be given for solutions obtained by numerical simulations.

Tesla Roadster Acceleration

The goals of this problem are to analytically estimate the 0-60 mph acceleration time t_a of the Tesla Roadster (the original Tesla EV). This is an analysis problem. Solutions based on simulation results will receive zero credit.

The estimated vehicle and induction motor specifications are approximately as follows:

- Maximum motor Torque T_{emax} = 370 Nm
- Maximum motor power P_{emax} = 225 kW
- Motor rpm at base speed n_{ebase} = 5400 rpm
- Maximum motor rpm, n_{emax} = 14000 rpm
- Maximum vehicle Speed v_{max} = 125 mph
- Curb weight (mass) M_v = 1235 kg
- Front Area A_v = 2 m^2
- Battery capacity = 60 kWh
- Reported range with a fully charged battery: 245 miles
- Drag coefficient C_d = 0.23

a) Sketch approximate plots of maximum vehicle tractive force F_v [N] and power P_v [kW] as functions of vehicle speed v, for speeds between 0 and 60 mph. Compute and label the plots with the values of the force and power at 0 mph, at base speed v_b, and at 60 mph.

b) Using the results of part (a), *solve approximately* for the acceleration time t_a from 0 to 60 mph. Assume that the vehicle is on a flat, concrete or asphalt road and that the coefficient of friction is C_r = 0.013. You may compare your result to the value reported by Tesla for the Roadster (t_a = 3.9 s).

c) Under the same assumptions as above, and assuming the Roadster drivetrain is 100% efficient, derive approximate expressions for and compute the following:
   - Cruising speed at which the vehicle would achieve the reported range. You may assume the vehicle is continuously moving at constant cruising speed.
   - Energy required to accelerate from 0 to 60 mph in time t_a. Give the result in kWh and as percent of the battery capacity.

Introduction to MATLAB/Simulink modeling and simulations

The purpose of this problem is to get started with using MATLAB/Simulink for modeling and simulations of electrified vehicles and EV components.

1. (this part of the assignment is not graded, no need to turn in anything) Carefully examine the simulation files provided in **EVModel_basic.zip**, and use MATLAB help or online resources to get up to speed with MATLAB and Simulink: examine operation of all blocks in the Simulink models and the MATLAB scripts provided in **EVModel_basic.zip**. A introductory lecture **Introduction to MATLAB/Simulink video** related to the files provided in **EVModel_basic.zip** has been posted in the Additional Materials and Resources, MATLAB/Simulink Resources section on D2L.

2. Referring to the model in **VehicleDynamics2.mdl** provided in **EVModel_basic.zip**, make modifications as needed and run simulations to obtain the following numerical values:

(a) Acceleration time from 60 mph to 80 mph, with the parameter values as originally given in the files provided.

(b) Acceleration time t_a from 0 mph to 60 mph for Tesla Roadster, with the vehicle and the motor parameters in the **Tesla Roadster Acceleration** problem.

In your solution, simply provide the numerical values obtained in parts 2.(a) and 2.(b). You do not need to provide any simulation files or to show any work.