Problem 1: Unstructured environment with no obstacles

min f(u, x)

1. r.t g(x) = 0 - satisfy vehicle dynamics, initial condition, goal (look ahead distance)

H(x) <= 0 - track, slip angle, steering rate, steering angle, force

f = w1\*t1 + w2\*dist\_to\_center\_line

1. Vehicle Model



Here s is the frenet coordinate along the track; α is the angle of centerline and hence a function of s. p is the design variables and h1 and h2 are the continuous input of acceleration and steering angle. h1 and h2 could be polynomial or spline.

For optimization, there are three variables of interest:



y1 is the integration end time; y2 is the deviation to the goal point and y3 is the average deviation from center line. We’ll need the Jacobian of y w.r.t p. So the problem in ode solver can be formulated as:



A forward integration from t0 to t1 by odeint can compute the value of y.