Problem 1

(50pt) Consider a Dubins' car dynamical system

$$\dot{x} = v\cos\theta$$
$$\dot{y} = v\sin\theta$$
$$\dot{\theta} = w$$

where v and w are linear and angular velocities of the vehicle.

- (10 pt) Recall in the class we discussed steering controller of a vehicle dynamical system. The goal of control is to reach a constant reference linear velocity $v_d = v_r$ with $x_d(t) = v_r t$ and $y_d = y_r$ and $\theta_d(t) = 0$ and $\omega_d = 0$. Let $v_r = 10$ and $y_r = 2$. Calculate the system dynamical model with respect to the deviation variables, that is $\mathbf{e}_x = [x - x_d, y - y_d, \theta - \theta_d]^T$ and $\mathbf{e}_u = [v - v_d, \omega - \omega_d]$.
- (10pt) Linearize the system at the reference trajectories using Jacobian linearization to obtain a linear approximation of the dynamical system with deviation variables.
- (10pt) design a feedback controller for steering control.
- (20pt) Implement the controller in matlab. In the ode45, please use the dubins' car dynamical model not the linearization. Plot the state trajectory given initial state $x(0) = 0$, $y(0) = 1$, and $v(0) = 8$. [optional] Experiments with different initial states and observe the controller performance.