```
clear all
close all
```

Trajectory Generation

Generate **minimum time** trajectory for a ground robot. The vehicle's dynamics are governed by

$\dot{p}_x = V\cos(\psi)$

$\dot{p}_y = V\sin(\psi)$

$\dot{\psi} = \omega$

Initial and final conditions are

$p_{init} = [0,0]^\top,\ \psi_{init} = \pi/3,$

$p_{fin} = [10,10]^\top,\ \psi_{fin} = \pi/3.$

The vehicle must obey to speed and angular rate constraints, i.e.,

$0 \le V \le 5 \qquad |\omega| \le 1.$

Finally, the vehicle must avoid an obstacle positioned at

$p_{obs} = [5,5]^\top$

by maintaining a minimum separation of $d_{sep} = 0.5$ from p_{obs}.

Load Parameters

```
CONSTANTS.N = 14; % Order of approximation
N = CONSTANTS.N;
CONSTANTS.pinit = [0;0];
CONSTANTS.pfin = [10;10];
CONSTANTS.headin = pi/3;
CONSTANTS.headout = pi/3;
CONSTANTS.pobs = [5 5]';
CONSTANTS.sep = 0.5;
CONSTANTS.vmax = 5;
CONSTANTS.omegamax = 1;
```

Initial guess

```
x1 = linspace(CONSTANTS.pinit(1),CONSTANTS.pfin(1),N+1)';
x2 = linspace(CONSTANTS.pinit(2),CONSTANTS.pfin(2),N+1)';
T = 10;
x0 = [x1;x2;T];
```

Linear Constraints and UL Bounds

```
A=[]; b=[]; Aeq=[]; beq=[]; lb=[]; ub=[];
```

Optimize

```
options = optimoptions(@fmincon,'Algorithm','sqp','MaxFunctionEvaluations',3000000);
tic
[x,f] = fmincon(@(x)costfun(x,CONSTANTS),x0,A,b,Aeq,beq,lb,ub,@(x)nonlcon(x,CONSTANTS),options)
```

```
Local minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in
feasible directions, to within the value of the optimality tolerance,
and constraints are satisfied to within the value of the constraint tolerance.

<stopping criteria details>
```

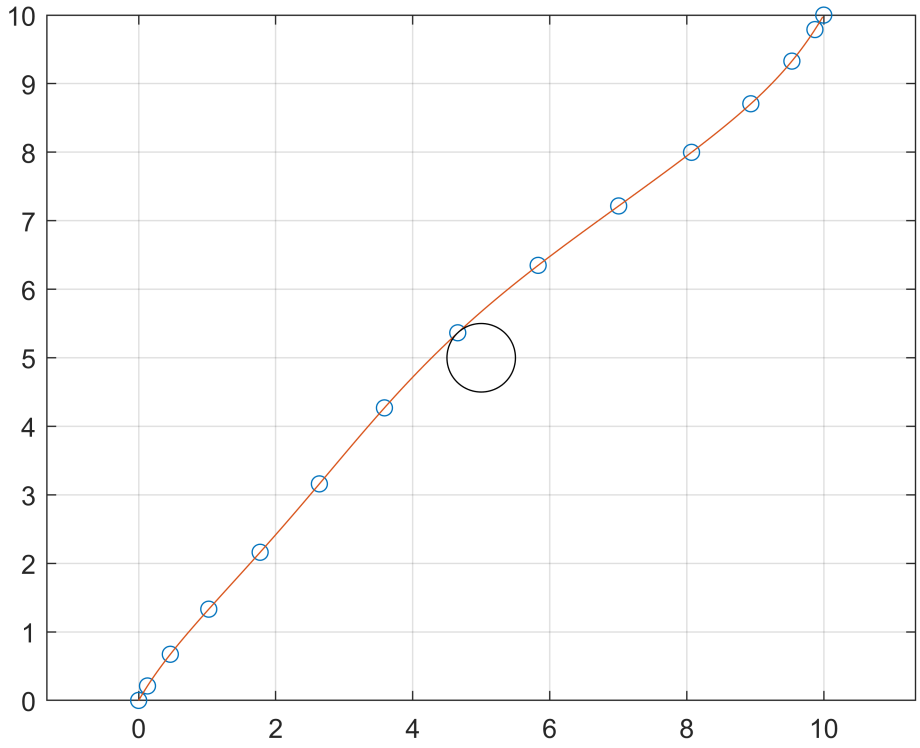
```
toc
```

```
Elapsed time is 0.239134 seconds.
```

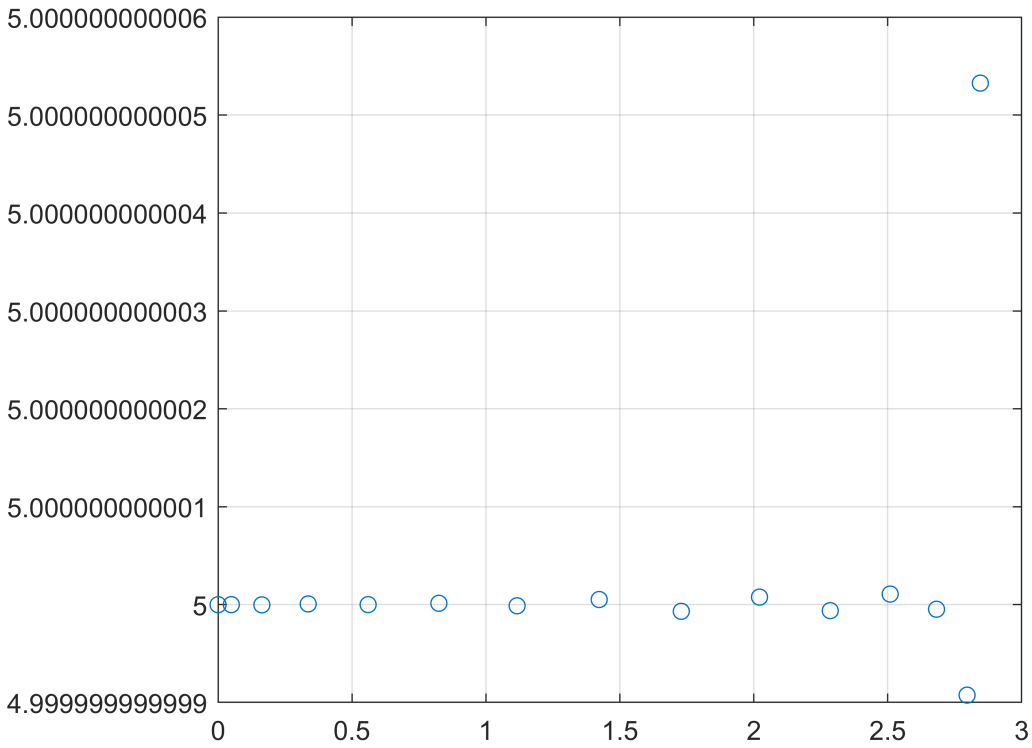
Plot

```
N = CONSTANTS.N;

%% Grab LGL Trajectories

x1 = x(1:N+1);
x2 = x(N+2:2*N+2);
T = x(end);

[tnodes,w,Diff] = LGL_PS(CONSTANTS.N,T);

u1 = x1'*Diff;
u2 = x2'*Diff;

unorm = sqrt((u1).^2+(u2).^2);


%% Plot
t = 0:0.01:T;
figure
plot(x1,x2,'o'); hold on
plot(LagrangePoly(x1,tnodes,t),LagrangePoly(x2,tnodes,t));
grid on
```

```
pos = [CONSTANTS.pobs(1)-CONSTANTS.sep CONSTANTS.pobs(2)-CONSTANTS.sep 2*CONSTANTS.sep 2*CONSTA
%pos = [1 2 4 4];
rectangle('Position',pos,'Curvature',[1 1])
axis equal
```




```
figure
plot(tnodes,unorm,'o'); hold on
grid on
```



Cost Function

```
function J = costfun(x,CONSTANTS)
%COSTFUN Summary of this function goes here
N = CONSTANTS.N;

T = x(end);

J = T;
end
```

Nonlinear Constraints

```
function [c,ceq] = nonlcon(x,CONSTANTS)
%NONLCON Summary of this function goes here
%   Detailed explanation goes here
N = CONSTANTS.N;

x1 = x(1:N+1);
x2 = x(N+2:2*N+2);
T = x(end);
```

```
[~,~,Diff] = LGL_PS(N,T);

u1 = x1'*Diff;
u2 = x2'*Diff;

unorm = sqrt((u1).^2+(u2).^2);

angle = atan2(u2,u1);

angrate = angle*Diff;

dist2obs = sqrt((x1-CONSTANTS.pobs(1)).^2 + (x2-CONSTANTS.pobs(2)).^2);


c=[unorm'-CONSTANTS.vmax;angrate'-CONSTANTS.omegamax;-angrate'-CONSTANTS.omegamax;angle'-pi/2;-
ceq=[x1(1)-CONSTANTS.pinit(1);x2(1)-CONSTANTS.pinit(2);x1(end)-CONSTANTS.pfin(1);x2(end)-CONSTA

end
```