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Assignment #1

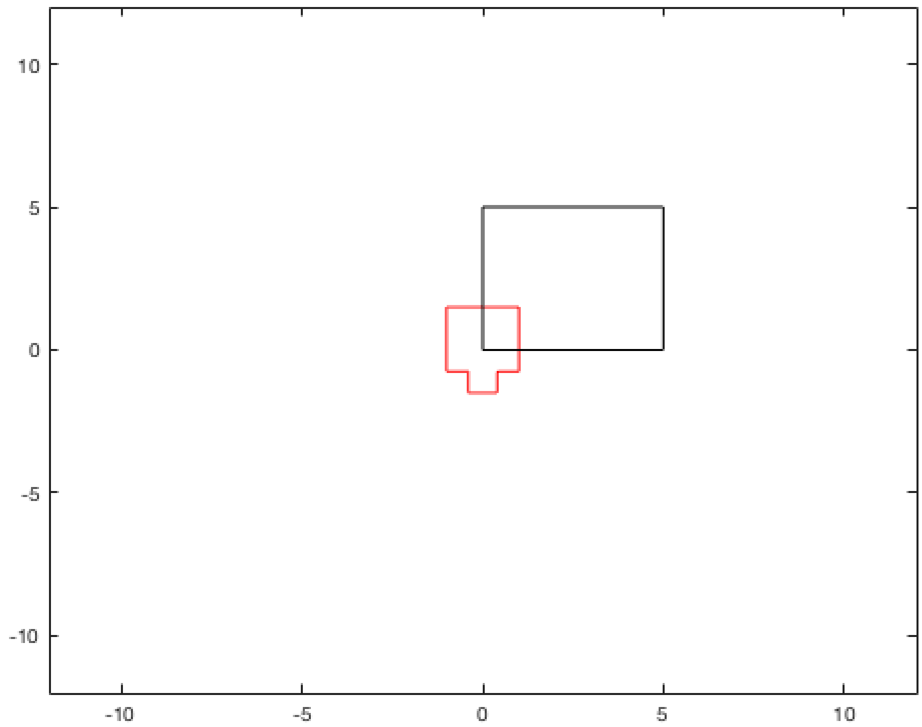
Students: Guilherme De Moura Araujo & Nicolas Buxbaum Professor: Stavros Vougioukas

```
close all; clear all; clc;
global route
global n
%global oldframe
```

Part 1a

```
%INPUTS
D = 5; % (m)
v = 1; % linear velocity (m/s)
w = pi/2; % angular velocity (rad/s)
wi = 2.0; % vehicle width (m)
r = 0.5; % wheel radius (m)
l = 3; % vehicle length (m)
dt = 0.05; % delta time (s)
sl = 0; %left slip (%)
sr = 0; % right sleep (%)
d = deg2rad(0); % delta (rad)
x = 0; % initial x pose
y = 0; % initial y pose
theta = deg2rad(0);
%route = [x,y];
route = zeros(2+4*(D/v/dt)+3*((pi/2)/w/dt),2);
tractor = draw_tractor(wi,l); % draw a vehicle element
% initial conditions prior to start the open loop
xp = x;
yp = y;
thetap = theta;
p1 = 0; p2 = 0; p3 = 0; p4 = 0; p5 = 0; p6 = 0; p7 = 0;
% Open loop
for i=0:dt:D/v-dt  %First side
    [xp,yp,thetap] = kinematic_ss(v,0,r,wi,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
    p1 = p1+1;
end
```

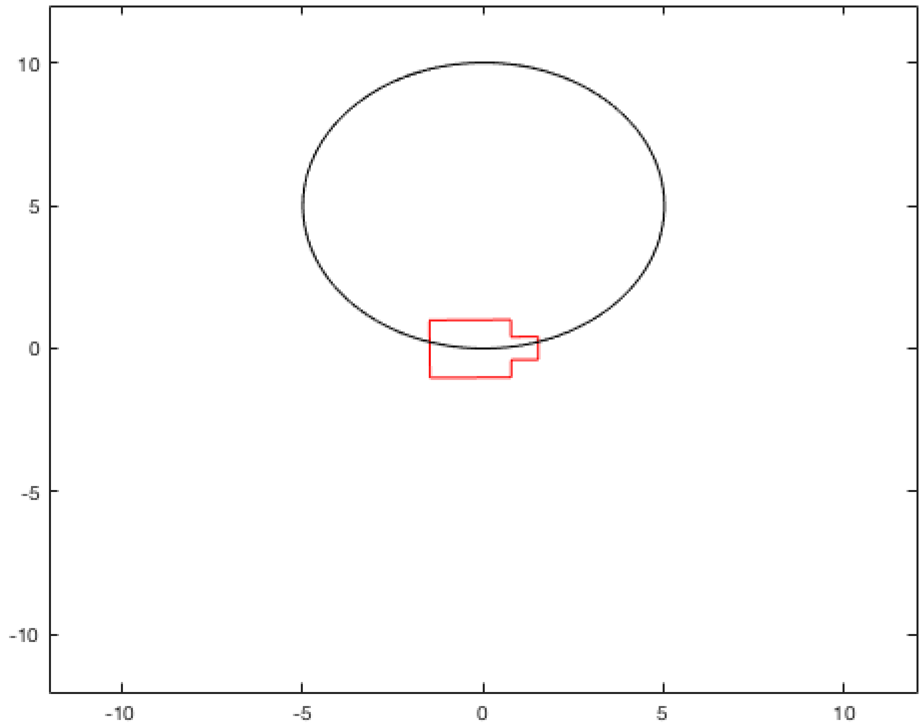
```
for i=0:dt:(pi/2)/w-dt %Vehicle turning
    [xp,yp,thetap] = kinematic_ss(0,w,r,wi,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
    p2 = p2+1;
end

for i=0:dt:D/v-dt  %Second side (notice that now theta = 90)
    [xp,yp,thetap] = kinematic_ss(v,0,r,l,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
    p3 = p3+1;
end

for i=0:dt:(pi/2)/w-dt %Vehicle turning
    [xp,yp,thetap] = kinematic_ss(0,w,r,wi,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
    p4 = p4+1;
end

for i=0:dt:D/v-dt   %Third side (theta = 180)
    [xp,yp,thetap] = kinematic_ss(v,0,r,l,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
    p5 = p5+1;
end

for i=0:dt:(pi/2)/w-dt %Vehicle turning
    [xp,yp,thetap] = kinematic_ss(0,w,r,wi,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
    p6 = p6+1;
end

for i=0:dt:D/v-dt %Third side (theta = 270)
    [xp,yp,thetap] = kinematic_ss(v,0,r,l,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
    p7 = p7+1;
end
route1 = route;
```



Part 1b

```
%INPUTS

n = 1;
v = 1; % m/s
R = 5; % meters
w = v/R; % radians/s
r = 0.5; % m
l = 3; % m
wi = 2; % m
dt = 0.05; % s
sl = 0; % %
sr = 0; % %
d = deg2rad(0); % rad
x = 0; % m
y = 0; % m
theta = deg2rad(0); % rad
route = [x,y];
tractor = draw_tractor(wi,l);
move_robot(x,y,theta,tractor);
xp = x;
yp = y;
thetap = theta;
```

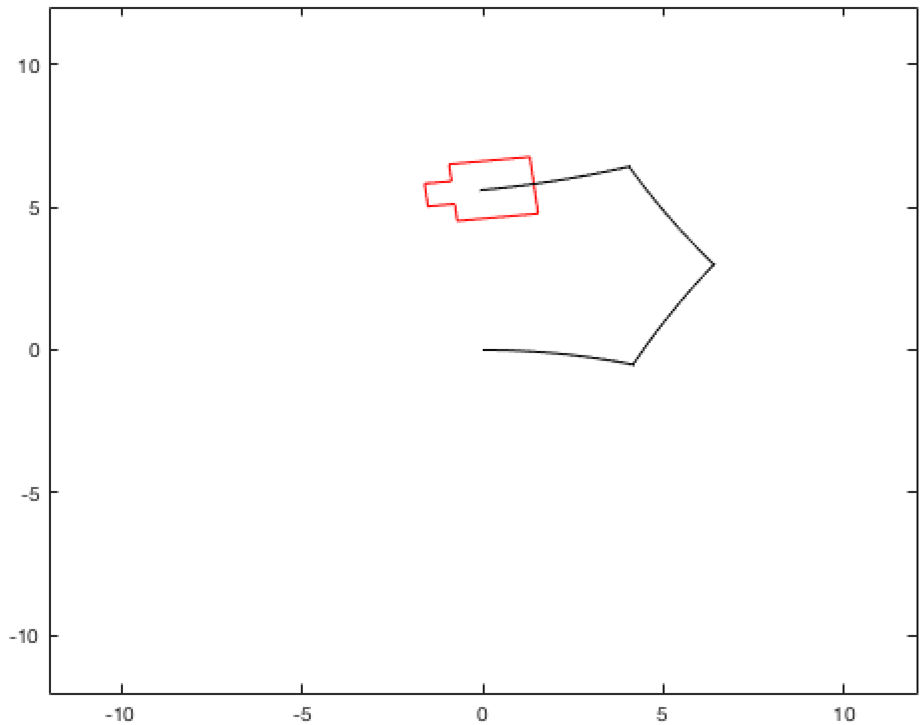
```
for i=0:dt:2*pi/w % Distance = 2pi, t = d/w
    [xp,yp,thetap] = kinematic_ss(v,w,r,l,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end
```



Part 2a

```
n = 1;
D = 5;
v = 1; % linear velocity
w = pi/2; % angular velocity
wi = 2.0; % vehicle width
r = 0.5; % wheel radius
l = 3; % vehicle length
dt = 0.05; % delta time
sl = 0.1; %left slip
sr = 0.2; % right sleep
d = deg2rad(0); % delta (angle)
x = 0; % initial x pose
y = 0; % initial y pose
theta = deg2rad(0);
route = zeros(2+4*(D/v/dt)+3*((pi/2)/w/dt),2);
tractor = draw_tractor(wi,l); % draw a vehicle element
% initial conditions prior to start the open loop
xp = x;
```

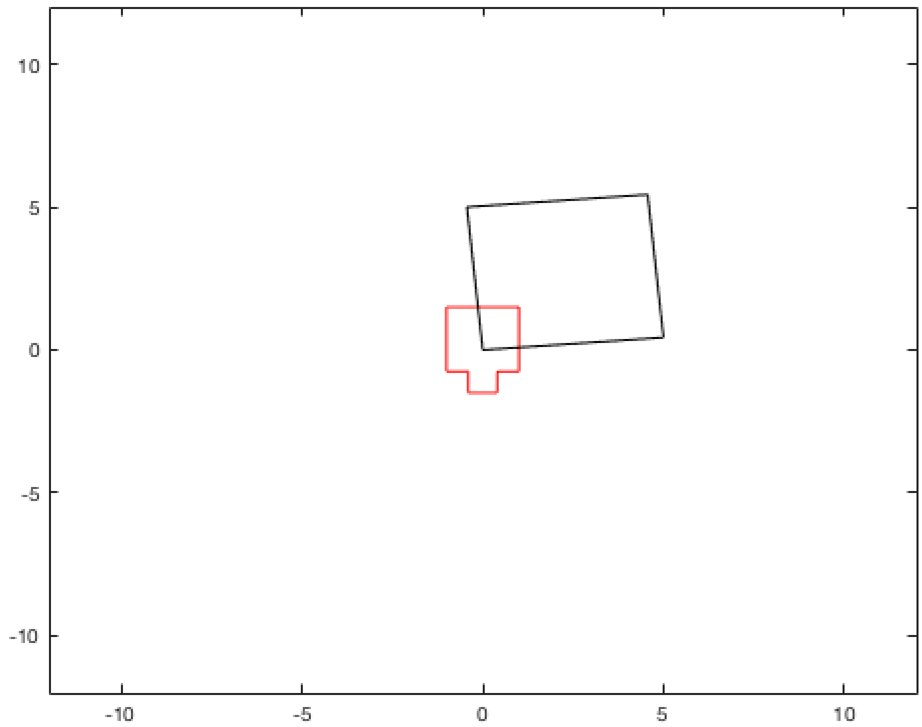
```
yp = y;
thetap = theta;
% Open loop
for i=0:dt:D/v-dt  %First side
    [xp,yp,thetap] = kinematic_ss(v,0,r,wi,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:(pi/2)/w-dt %Vehicle turning
    [xp,yp,thetap] = kinematic_ss(0,w,r,wi,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:D/v-dt  %Second side (notice that now theta = 90)
    [xp,yp,thetap] = kinematic_ss(v,0,r,l,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:(pi/2)/w-dt %Vehicle turning
    [xp,yp,thetap] = kinematic_ss(0,w,r,wi,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:D/v-dt   %Third side (theta = 180)
    [xp,yp,thetap] = kinematic_ss(v,0,r,l,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:(pi/2)/w-dt %Vehicle turning
    [xp,yp,thetap] = kinematic_ss(0,w,r,wi,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:D/v-dt %Fourth side (theta = 270)
    [xp,yp,thetap] = kinematic_ss(v,0,r,l,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end
route2 = route;
```



Part 2b

```
n = 1;
D = 5;
v = 1; % linear velocity
w = pi/2; % angular velocity
wi = 2.0; % vehicle width
r = 0.5; % wheel radius
l = 3; % vehicle length
dt = 0.05; % delta time
sl = 0.0; %left slip
sr = 0.0; % right sleep
d = deg2rad(5); % delta (angle)
x = 0; % initial x pose
y = 0; % initial y pose
theta = deg2rad(0);
route = zeros(2+4*(D/v/dt)+3*((pi/2)/w/dt),2);
tractor = draw_tractor(wi,l); % draw a vehicle element
% initial conditions prior to start the open loop
xp = x;
yp = y;
thetap = theta;
% Open loop
for i=0:dt:D/v-dt  %First side
    [xp,yp,thetap] = kinematic_ss(v,0,r,wi,dt,sl,sr,d,xp,yp,thetap);
```

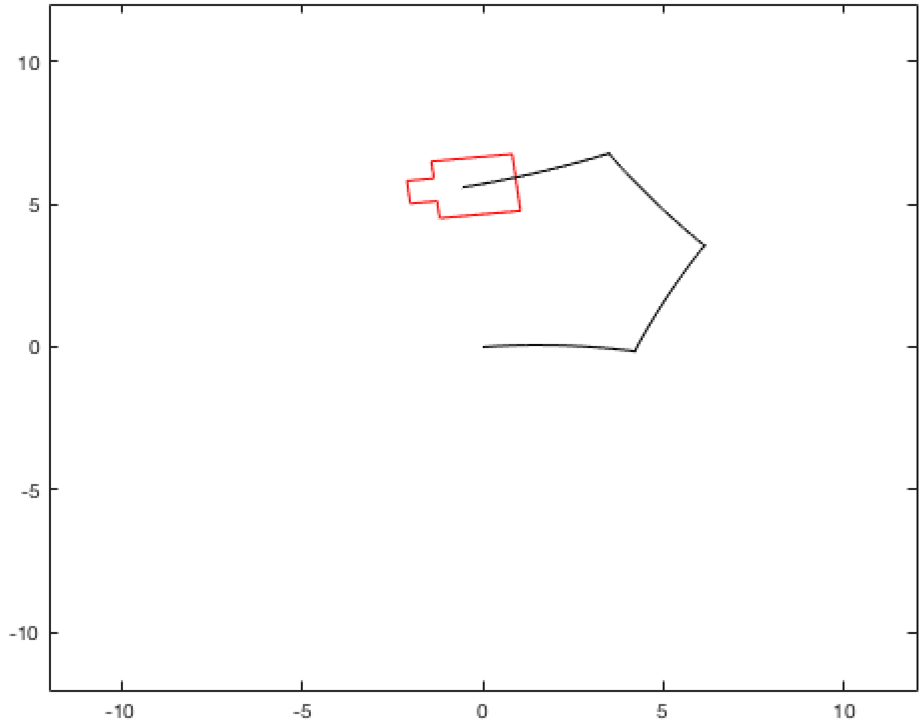
```
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:(pi/2)/w-dt %Vehicle turning
    [xp,yp,thetap] = kinematic_ss(0,w,r,wi,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:D/v-dt  %Second side (notice that now theta = 90)
    [xp,yp,thetap] = kinematic_ss(v,0,r,l,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:(pi/2)/w-dt %Vehicle turning
    [xp,yp,thetap] = kinematic_ss(0,w,r,wi,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:D/v-dt   %Third side (theta = 180)
    [xp,yp,thetap] = kinematic_ss(v,0,r,l,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:(pi/2)/w-dt %Vehicle turning
    [xp,yp,thetap] = kinematic_ss(0,w,r,wi,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:D/v-dt %Fourth side (theta = 270)
    [xp,yp,thetap] = kinematic_ss(v,0,r,l,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end
route3 = route;
```



Part 2c

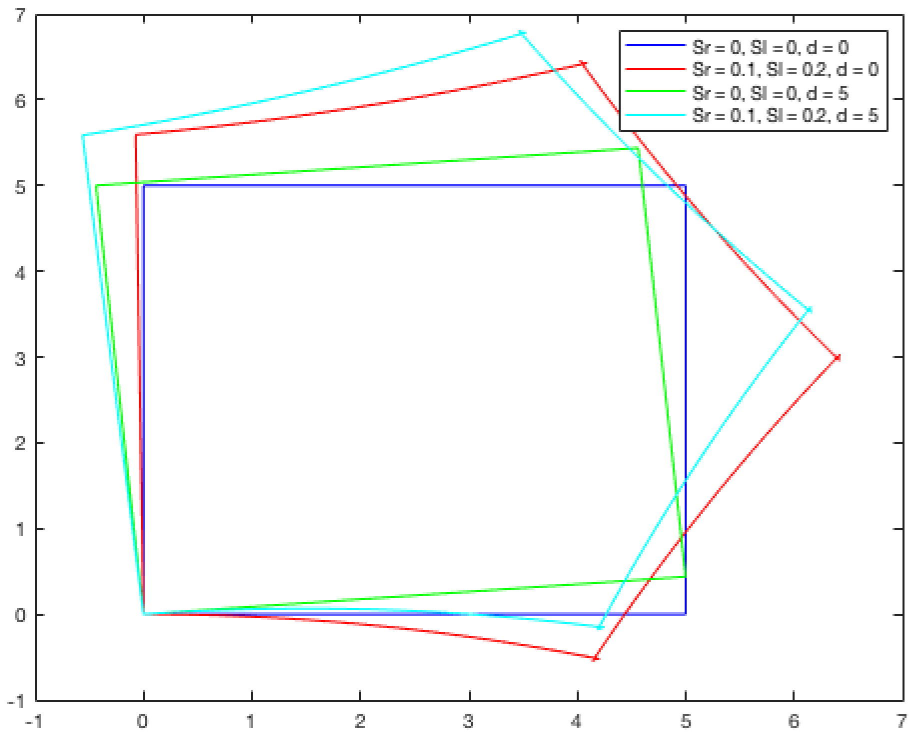
```
n = 1;
D = 5;
v = 1; % linear velocity
w = pi/2; % angular velocity
wi = 2.0; % vehicle width
r = 0.5; % wheel radius
l = 3; % vehicle length
dt = 0.05; % delta time
sl = 0.1; %left slip
sr = 0.2; % right sleep
d = deg2rad(5); % delta (angle)
x = 0; % initial x pose
y = 0; % initial y pose
theta = deg2rad(0);
route = zeros(2+4*(D/v/dt)+3*((pi/2)/w/dt),2);
tractor = draw_tractor(wi,l); % draw a vehicle element
% initial conditions prior to start the open loop
xp = x;
yp = y;
thetap = theta;
% Open loop
for i=0:dt:D/v-dt  %First side
    [xp,yp,thetap] = kinematic_ss(v,0,r,wi,dt,sl,sr,d,xp,yp,thetap);
```

```
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:(pi/2)/w-dt %Vehicle turning
    [xp,yp,thetap] = kinematic_ss(0,w,r,wi,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:D/v-dt  %Second side (notice that now theta = 90)
    [xp,yp,thetap] = kinematic_ss(v,0,r,l,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:(pi/2)/w-dt %Vehicle turning
    [xp,yp,thetap] = kinematic_ss(0,w,r,wi,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:D/v-dt   %Third side (theta = 180)
    [xp,yp,thetap] = kinematic_ss(v,0,r,l,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:(pi/2)/w-dt %Vehicle turning
    [xp,yp,thetap] = kinematic_ss(0,w,r,wi,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end

for i=0:dt:D/v-dt %Fourth side (theta = 270)
    [xp,yp,thetap] = kinematic_ss(v,0,r,l,dt,sl,sr,d,xp,yp,thetap);
    move_robot(xp,yp,thetap,tractor);
end
route4 = route;
```



3. PLOTS

```
figure;
plot(route1(:,1),route1(:,2),'b-')
hold on
plot(route2(:,1),route2(:,2),'r-')
plot(route3(:,1),route3(:,2),'g-')
plot(route4(:,1),route4(:,2),'c-')
legend('Sr = 0, Sl = 0, d = 0','Sr = 0.1, Sl = 0.2, d = 0','Sr = 0, Sl
 = 0, d = 5','Sr = 0.1, Sl = 0.2, d = 5')
```



3a Plot Comments

sl=0, sr=0, ?=0 is a no slip and no skip condition. As expected, the kinematic model yields positions that precisely follow the shape of a 5m square. **sl=0.1, sr=0.2, ?=0** is a slip no skid condition. Normally in a straght path the vehicle anglular velocity is 0. However with the presence of uneven slip in both wheels, the vehicle turns due to non-equal left and right wheel angular velocities resulting in a changing theta value. **sl=0.1, sr=0.2, ?=5o** is a slip and skid condition. The robot expereinces both a changing theta during the straight line path and a lateral velocity Vy. **sl=0, sr=0, ?=5o** is a no skip skid condition. The vehicle path is at angle with the desired path due to the presence of lateral velocity Vy. With both slips zero theta is zero and the vehicle angular velocity is also 0 (and the robot travels the correct longitudinal distance).

4. Integration Step ?t

With an increased integration step, the kinematic model creates longer linear movements between points. The robot also is plotted roughly ten times as fast. The effect is most noticible in the circular path, shown in the figure below.

```
%
```

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