Contents

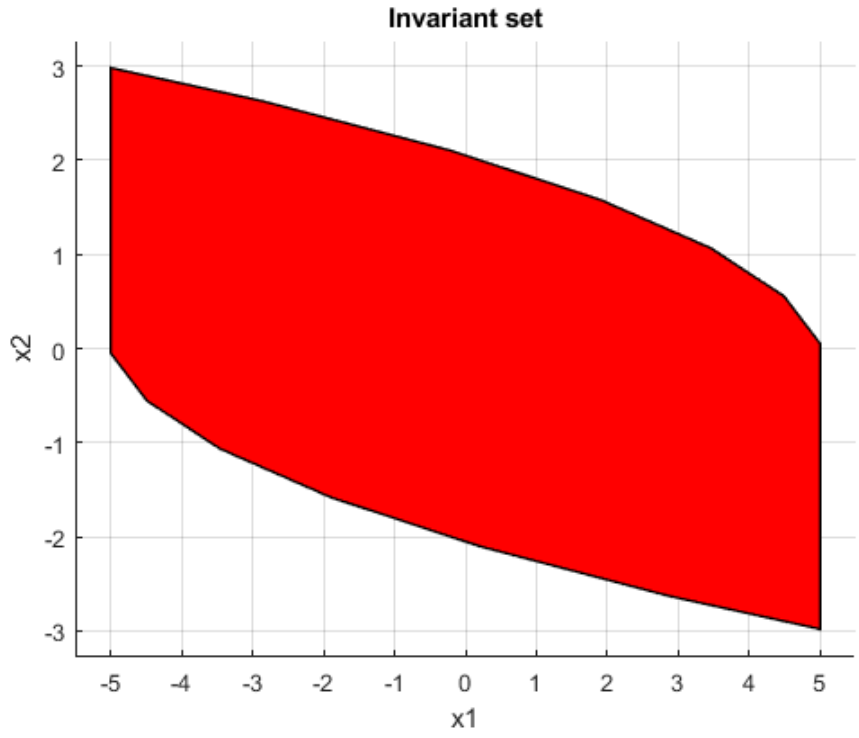
HW 7 Question 4

```
clc
clear all
close all
dbstop if error
```

Question 1

```
A = [0.99 1;
    0 0.99];
B = [0;1];

% computes a control invariant set for LTI system x^+ = A*x+B*u
system = LTISystem('A', A, 'B', B);
system.x.min = [-5; -5];
system.x.max = [5; 5];
system.u.min = -0.5;
system.u.max = 0.5;
Xf = system.invariantSet();
Xf.plot()
xlabel('x1')
ylabel('x2')
title('Invariant set')

% Compute a terminal cost from the Lyapunov equation
Q =[1 0;
    0 1];
R =1;
PN = dlyap(A',Q);
```

```
Iteration 1...
Iteration 2...
Iteration 3...
Iteration 4...
Iteration 5...
Iteration 6...
Iteration 7...
```



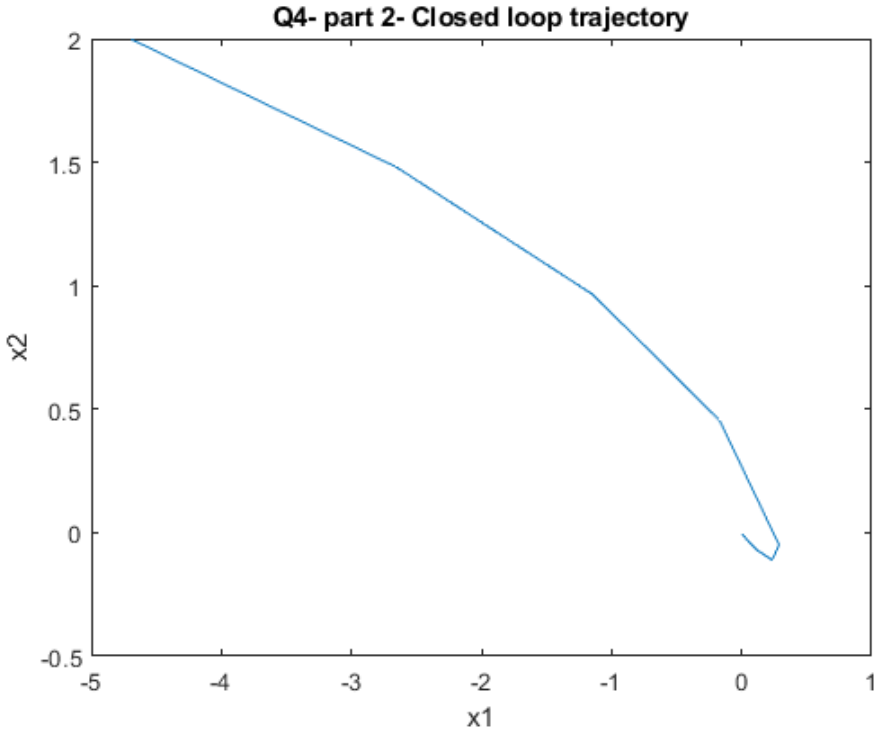
Question 2

Create an online MPC controller

```
clear system
tic
system = LTISystem('A', A, 'B', B);
system.x.min = [-5; -5];
system.x.max = [5; 5];
system.u.min = -0.5;
system.u.max = 0.5;
Xf = system.invariantSet();
system.x.penalty = QuadFunction(Q);
system.u.penalty = QuadFunction(R);

system.x.with('terminalSet');
system.x.terminalSet = Xf;
system.x.with('terminalPenalty');
system.x.terminalPenalty = QuadFunction(PN);

x0 = [-4.7;2];
N = 4;
mpc = MPCController(system, N);

[u, feasible, openloop] = mpc.evaluate(x0)
loop = ClosedLoop(mpc, system);
data = loop.simulate(x0, 30);
onlineTime = toc;

% Plot trajectory
figure
plot(data.X(1,:),data.X(2,:))
title('Q4- part 2- Closed loop trajectory')
xlabel('x1')
ylabel('x2')
```

```
Iteration 1...
Iteration 2...
```

```
Iteration 3...
Iteration 4...
Iteration 5...
Iteration 6...
Iteration 7...

u =

   -0.5000


feasible =

  logical

   1


openloop =

  struct with fields:

    cost: 40.8544
       U: [-0.5000 -0.5000 -0.5000 -0.4539]
       X: [2×5 double]
       Y: [0×4 double]
```

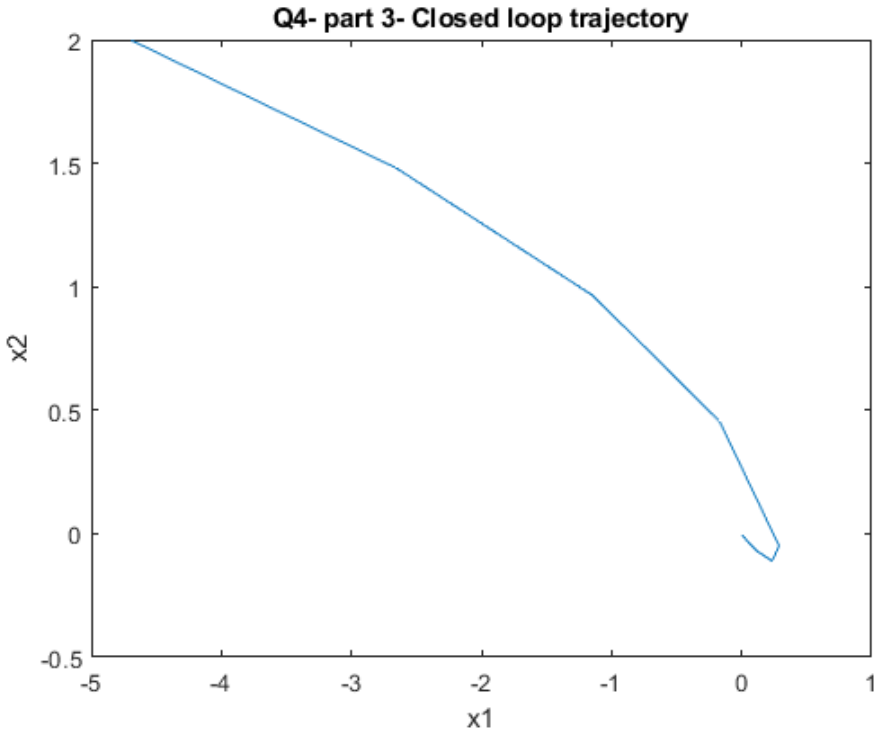


Question 3

```
clear system
clear mpc
tic
system = LTISystem('A', A, 'B', B);
system.x.min = [-5; -5];
system.x.max = [5; 5];
system.u.min = -0.5;
system.u.max = 0.5;
Xf = system.invariantSet();
```

```
system.x.penalty = QuadFunction(Q);
system.u.penalty = QuadFunction(R);
system.x.with('terminalSet');
system.x.terminalSet = Xf;
system.x.with('terminalPenalty');
system.x.terminalPenalty = QuadFunction(PN);
x0 = [-4.7;2];
N = 4;
mpc = MPCController(system, N);
expmpc = mpc.toExplicit();
[u, feasible, openloop] = expmpc.evaluate(x0)
loop = ClosedLoop(expmpc, system);
data2 = loop.simulate(x0, 30);
explicitTime = toc;

% Plot trajectory
figure
plot(data2.X(1,:),data2.X(2,:))
title('Q4- part 3- Closed loop trajectory')
xlabel('x1')
ylabel('x2')
```

```
Iteration 1...
Iteration 2...
Iteration 3...
Iteration 4...
Iteration 5...
Iteration 6...
Iteration 7...
mpt_plcp: 33 regions

u =

   -0.5000


feasible =

  logical

   1


openloop =

  struct with fields:

         cost: 40.8544
            U: [-0.5000 -0.5000 -0.5000 -0.4539]
            X: [2×5 double]
            Y: [0×4 double]
    partition: 1
       region: 8
```



Question 4

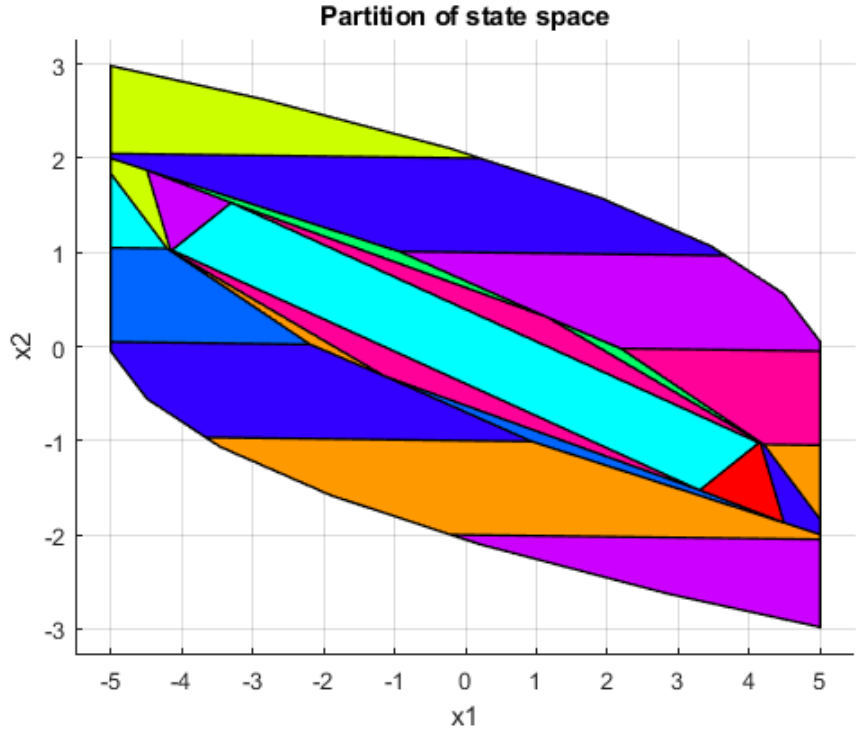
Table the two execution times

```
names = {'Online controller';'Explicit controller'};
times = {onlineTime; explicitTime};
T = cell2table([names, times],'VariableNames',{'Controller','ExecutionTime'})
```

```
T =

  2×2 table

        Controller          ExecutionTime
    ____________________    _____________

    'Online controller'       2.6131
    'Explicit controller'    0.93478
```

Question 5

```
figure
expmpc.partition.plot()
title('Partition of state space')
xlabel('x1')
ylabel('x2')
```



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