College of Engineering
School of Aeronautics and Astronautics

AAE 36401 Lab
Control Systems Lab

Lab 3 Pre-Lab
The Control of the Inverted Pendulum

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The gains using Pole Placement:

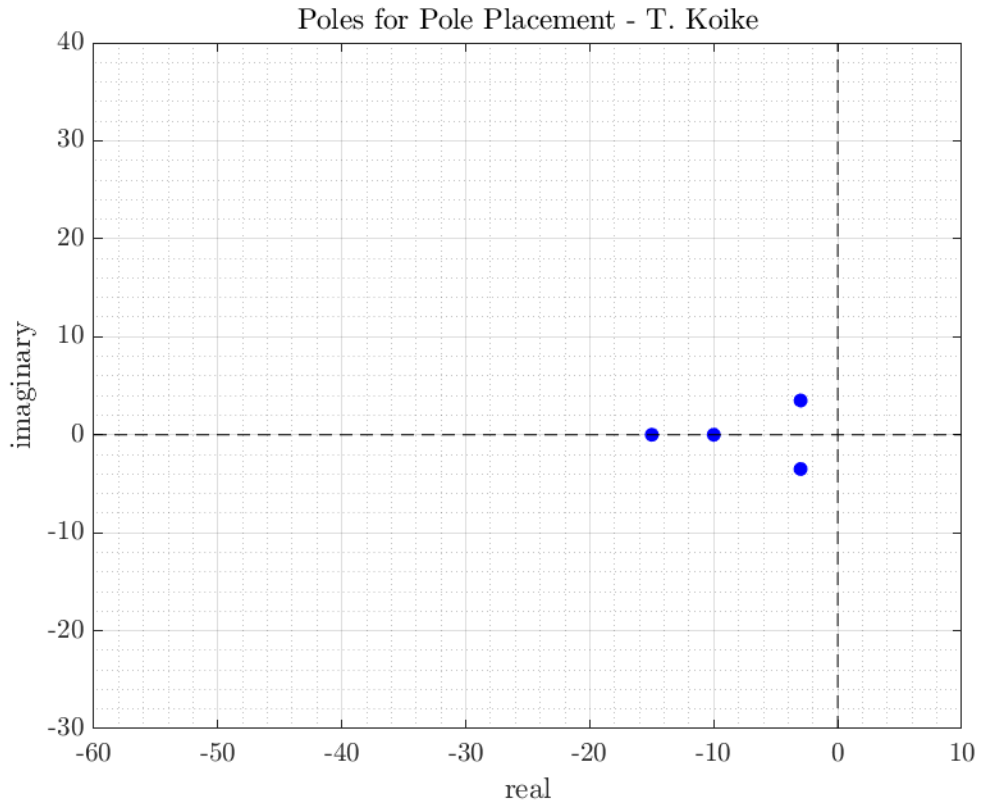
K_1	K_2	K_3	K_4
-47.9001	67.5785	-29.6405	9.5819

The gains using LQR:

K_1	K_2	K_3	K_4
-18.7083	74.5253	-26.4867	9.5819

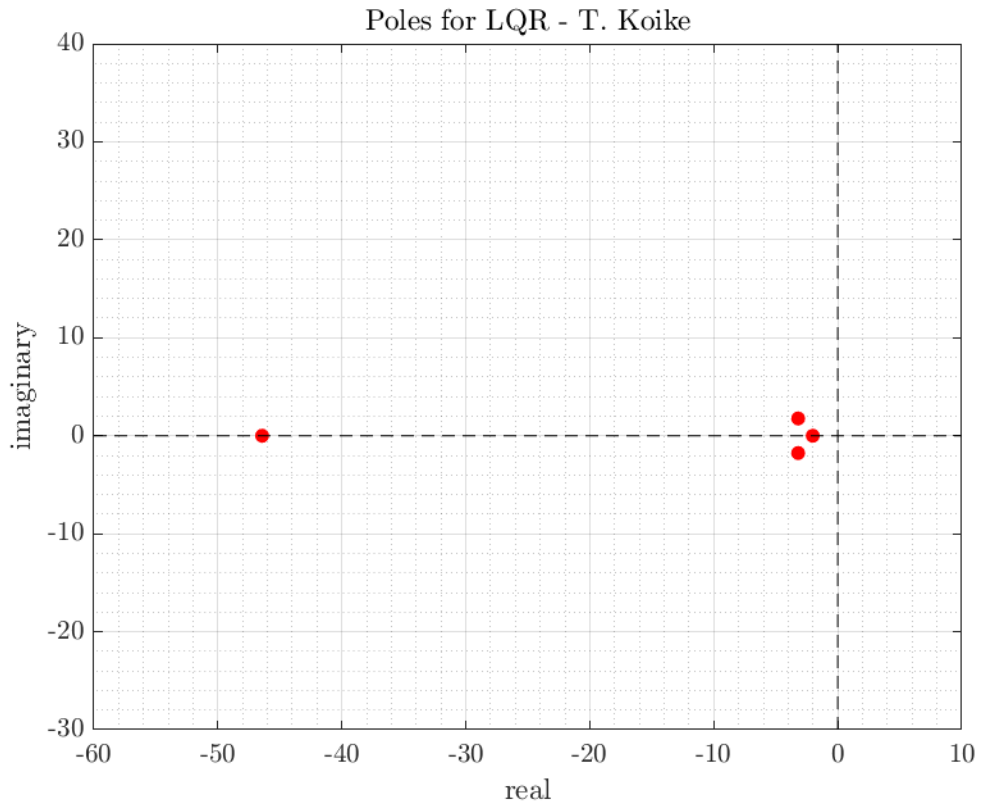
The poles for Pole Placement:

λ_1	λ_2	λ_3	λ_4
-3+3.5i	-3-3.5i	-10	-15

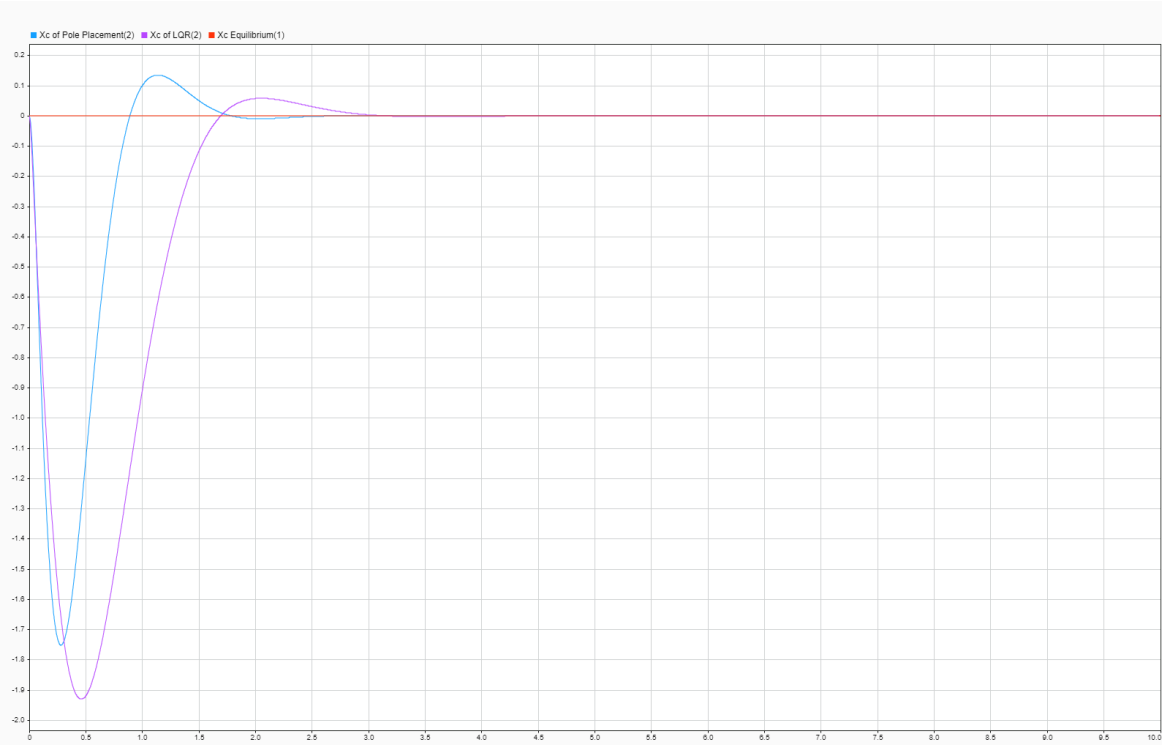


The poles for LQR:

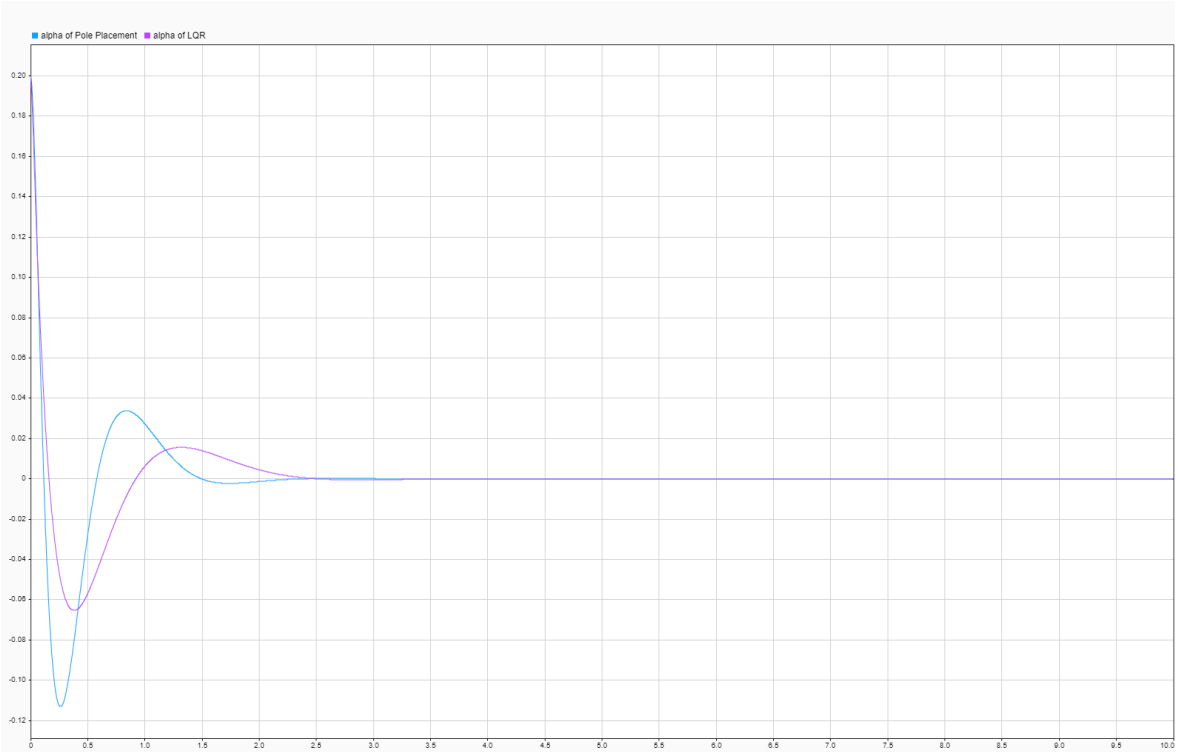
λ_1	λ_2	λ_3	λ_4
-46.4366	-3.1942+1.7633i	-3.1942-1.7633i	-2.0139



The Xc for the pole placement and LQR is plotted as below



The pendulum angle alpha for the pole placement and LQR is plotted as below



MATLAB CODE

```
% AAE364L pre-lab3
% Tomoki Koike
clear all; close all; clc;
set(groot, 'defaulttextinterpreter','latex');
set(groot, 'defaultAxesTickLabelInterpreter','latex');
set(groot, 'defaultLegendInterpreter','latex');
setup_lab_ip01_2_sip;
```

```
% Get the poles and plot them

% Pole Placement
lambda1 = -3+3.5i;
lambda2 = conj(lambda1);
lambda3 = -10;
lambda4 = -15;
lambdas_pp = [lambda1, lambda2, lambda3, lambda4];
K_pp = place(A, B, lambdas_pp)
K = K_pp;
sim('s_sip_lqr.mdl')
```

```
% LQR - Linear Quadratic Regulator
diagonal = diag([35, 35, 0, 2]);
K_lqr = lqr(A, B, diagonal, 1/100)
K = K_lqr;
lambdas_lqr = eig(A-B*K_lqr);
sim('s_sip_lqr.mdl')
```

```
% Plotting
fig0 = figure();
plot(real(lambdas_pp), imag(lambdas_pp), 'b.', 'MarkerSize', 18)
title('Poles for Pole Placement - T. Koike')
xlabel('real')
ylabel('imaginary')
hold on
plot(linspace(-60,10,2^6), 0*linspace(-60,10,2^6),'--k')
plot(0*linspace(-30,40,2^6), linspace(-30,40,2^6),'--k')
hold off
grid on; grid minor; box on;
xlim([-60, 10]); ylim([-30, 40]);

fig1 = figure();
plot(real(lambdas_lqr), imag(lambdas_lqr), 'r.', 'MarkerSize', 18)
title('Poles for LQR - T. Koike')
xlabel('real')
ylabel('imaginary')
hold on
plot(linspace(-60,10,2^6), 0*linspace(-60,10,2^6),'--k')
plot(0*linspace(-30,40,2^6), linspace(-30,40,2^6),'--k')
hold off
grid on; grid minor; box on;
```

```
xlim([-60, 10]); ylim([-30, 40]);

saveas(fig0, 'labP_pole_pp.png');
saveas(fig1, 'labP_pole_lqr.png');
```