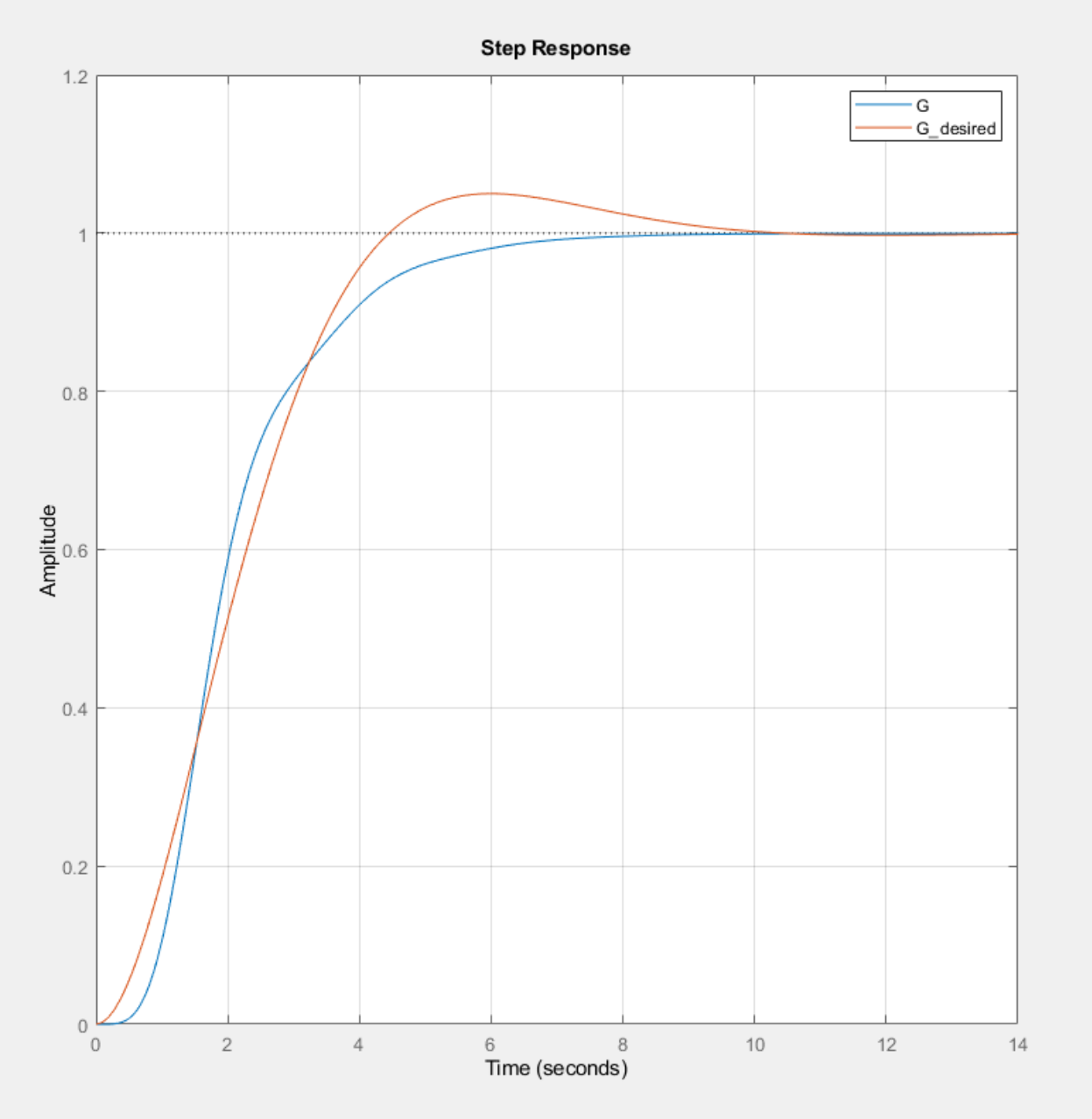
```
>> clear all
>> [X,fval] = fminsearch(@(X) err_from_Q_a_b(X),[1,1])

X =

  677.5260  422.9956


fval =

    1.7058

>> lqr_test_script

Q =

  677.5260         0         0         0         0
         0         0         0         0         0
         0         0         0         0         0
         0         0         0         0         0
         0         0         0         0  422.9956


Kx =

  -49.2998   84.6513  -30.8701   20.5731


Kz =

  -20.5669

fx >>
```

```
function [err] = err_from_Q_a_b(X)
a = X(1); b = X(2);

if a<0 || b<0
    err = 1e3;
    return
end

% mc = 1; ml = 4; L = 1;
% [A,B] = linearizedCartPend(mc,ml,L);
mball = 0.5; Rball=1; mbeam = 4.8990; L = 2.4746;
[A,B] = linearizedBeamBall(mball,Rball,mbeam,L);
C = [1 0 0 0];
Aaug = [A, zeros(4,1); C, 0]; Baug = [B;0]; Caug = [C,0];
Cz = [0 0 0 0 1];
Qx = Caug'*Caug;
Qz = Cz'*Cz;

Q = a*Qx + b*Qz;
R = 1;

[K,S,CLP] = lqr(Aaug,Baug,Q,R);

Kx = K(1:4); Kz = K(5);
Acl = [A-B*Kx, -B*Kz; C, 0]; Bcl = [zeros(4,1); -1]; Ccl = Caug; Dcl = 0;
G = ss(Acl, Bcl, Ccl, Dcl);

des_dom_poles = [-0.5+0.5243j, -0.5-0.5243j];
num = abs(des_dom_poles(1))^2;
den = poly(des_dom_poles);
Gd = tf(num,den);

Tend = 15;
err = resp_err(G,Gd,Tend);

end
```

```
%% Desired response
des_dom_poles = [-0.5+0.5243j, -0.5-0.5243j];
num = abs(des_dom_poles(1))^2;
den = poly(des_dom_poles);
Gd = tf(num,den);

%% Current system
mball = 0.5; Rball=1; mbeam = 4.8990; L = 2.4746;
[A,B] = linearizedBeamBall(mball,Rball,mbeam,L);
C = [1 0 0 0];
Aaug = [A, zeros(4,1); C, 0]; Baug = [B;0]; Caug = [C,0];
Cz = [0 0 0 0 1];

%% Check controllability
% OO = [Baug, Aaug*Baug, Aaug^2*Baug, Aaug^3*Baug, Aaug^4*Baug, Aaug^5*Baug];
% rankOO = rank(OO)
% return

%% Observer
Qx = Caug'*Caug;
Qz = Cz'*Cz;
a = 677.5260; b = 422.9956;
Q = a*Qx + b*Qz
R = 1;

[K,S,CLP] = lqr(Aaug,Baug,Q,R);

Kx = K(1:4)
Kz = K(5)
% Acl = [A-B*Kx, -B*Kz; C, 0]; Bcl = [zeros(4,1); -1]; Ccl = Caug; Dcl = 0;


%% Test
G = ss(Acl, Bcl, Ccl, Dcl);
step(G)
hold on;
step(Gd)
legend('G','G_{desired}');
grid on;

resp_err(G,Gd,15)
```


Step Response
G
G_desired
Amplitude
Time (seconds)
0
0.2
0.4
0.6
0.8
1
1.2
0
2
4
6
8
10
12
14