```
clear; close all; clc;

problem1()

problem2()

problem3()

problem4()
```

Functions

```
function problem1()
    fprintf("\nProblem 1:\n")
    A = [-1.10188, 0.90528, -.00212;
           4.0639, -.77013, -.169190;
            0,           0,        10];
    B = [0, 0;
         0, 1;
         10, 0];
    C = eye(3);

    lam1 = -2+2i;
    lam2 = conj(lam1);
    lam3 = -15;
    des_poles = [lam1, lam2, lam3];

    vec1 = [0.20 - .35i, -.98 - .07i, 0]';
    vec2 = conj(vec1);
    vec3 = [0; 0; 1];
    des_vec = [vec1, vec2, vec3];

    EigStructAssign(A, B, C, des_poles, des_vec);

end

function problem2()
    fprintf("\nProblem 2:\n")
    A = [-1.10188, 0.90528, -.00212;
           4.0639, -.77013, -.169190;
           0,      0,       10];
    B = [0,  0;
         0,  1;
         10, 0];
    C = [1, 0, 0;
         0, 1, 0];

    lam1 = -2+2i;
    lam2 = conj(lam1);
    des_poles = [lam1, lam2];

    vec1 = [0.20 - .35i, -.98 - .07i]';
```

```
    vec2 = conj(vec1);
    des_vec = [vec1, vec2];

    EigStructAssign(A, B, C, des_poles, des_vec);
    fprintf("The acuator pole is moved from -15 to 9.5 now that we are not
 \n")
    fprintf("able to directly assign the actuator pole\n\n")
end

function problem3()
    fprintf("\nProblem 3:\n")
    A = [-1.10188, 0.90528, -.00212;
           4.0639, -.77013, -.169190;
           0,      0,       10];
    B = [0,  0, 10]';
    C = [1, 0, 0;
         0, 1, 0];

    lam1 = -2+2i;
    lam2 = conj(lam1);
    des_poles = [lam1, lam2];

    vec1 = [0.20 - .35i, -.98 - .07i]';
    vec2 = conj(vec1);
    des_vec = [vec1, vec2];

    EigStructAssign(A, B, C, des_poles, des_vec);
    fprintf("The actuator pole has moved increasingly positive to 12.15\n\n")
end

function problem4()
fprintf("\nProblem 4:\n")
    A = [0, 1;
        -2, -3];
    poles = eig(A);
    fprintf("Open Loop Poles are \\lamda = \n")
    disp(poles)
    fprintf("The poles are negative so the open loop system is stable\n")
    B = [0; 2];
    Ackermann(A, B);
end

function K = Ackermann(A, B)
    n = length(A);

    syms s
    fdes_s = collect((s+3)*(s+5));
    coef = sym2poly(fdes_s);
    fdes_A = coef(1).*A*A + coef(2).*A + coef(3).*eye(n);

    Con = [];
    for ii = 1:n
        Con = [Con, A^(ii-1)*B];
    end
```

```
    leftv = [zeros(1,n-1), 1];
    K = leftv*inv(Con)*fdes_A;
    fprintf("Control Gains are K = \n")
    disp(K)
end

function K = EigStructAssign(A, B, C, des_lambda, des_vec)
    poles = eig(A);
    fprintf("Open Loop Poles are \\lamda = \n")
    disp(poles)

    cont_matrix = [B, A*B, A^2*B];
    fprintf("Controllable since controllability matrix is rank %i and A is
 rank %i\n\n", [rank(cont_matrix), rank(A)])

    n = length(A);
    m = size(B,2);
    p = length(des_lambda);

    I = eye(n);
    D = diag(ones(1,p));
    O = zeros(p,(n+m)-p);
    top = zeros(n,1);
    uv = @(lambda,vec) pinv([lambda.*I - A, B; D, O])*[top;vec];

    for ii = 1:p
        uvii = uv(des_lambda(ii), des_vec(:,ii));
        vd(:,ii) = uvii(1:n);
        ud(:,ii) = uvii(n+1:end);
    end
    K = ud*inv(C*vd);
    fprintf("Control Gains are K = \n")
    disp(K)
    poles = eig(A-B*K*C);
    fprintf("Closed Loop Poles are \\lamda = \n")
    disp(poles)
    fprintf("Desired Eigen Vectors are v = \n")
    disp(des_vec)
    fprintf("Achievable Eigen Vectors are v = \n")
    disp(vd)
end
```

```
Problem 1:
Open Loop Poles are \lamda =
   -2.8612
    0.9892
   10.0000

Controllable since controllability matrix is rank 3 and A is rank 3

Control Gains are K =
   0.0000 - 0.0000i   0.0000 + 0.0000i   2.5000 + 0.0000i
```

```
   9.3880 + 0.0000i   2.1373 + 0.0000i  -0.1699 - 0.0000i

Closed Loop Poles are \lamda =
  -2.0047 + 2.0012i
  -2.0047 - 2.0012i
 -15.0000 - 0.0000i

Desired Eigen Vectors are v =
   0.2000 + 0.3500i   0.2000 - 0.3500i   0.0000 + 0.0000i
  -0.9800 + 0.0700i  -0.9800 - 0.0700i   0.0000 + 0.0000i
   0.0000 + 0.0000i   0.0000 + 0.0000i   1.0000 + 0.0000i

Achievable Eigen Vectors are v =
   0.1943 + 0.3553i   0.1943 - 0.3553i   0.0002 + 0.0000i
  -0.9790 + 0.0730i  -0.9790 - 0.0730i   0.0000 + 0.0000i
  -0.0000 - 0.0000i  -0.0000 + 0.0000i   1.0000 + 0.0000i


Problem 2:
Open Loop Poles are \lamda =
   -2.8612
    0.9892
   10.0000

Controllable since controllability matrix is rank 3 and A is rank 3

Control Gains are K =
 -33.9273 - 0.0000i  -0.4173 + 0.0000i
  14.4728 + 0.0000i   2.5964 - 0.0000i

Closed Loop Poles are \lamda =
   9.5316 + 0.0000i
  -2.0000 - 2.0000i
  -2.0000 + 2.0000i

Desired Eigen Vectors are v =
   0.2000 + 0.3500i   0.2000 - 0.3500i
  -0.9800 + 0.0700i  -0.9800 - 0.0700i

Achievable Eigen Vectors are v =
   0.2000 + 0.3500i   0.2000 - 0.3500i
  -0.9800 + 0.0700i  -0.9800 - 0.0700i
  -3.5615 -10.5134i  -3.5615 +10.5134i

The acuator pole is moved from -15 to 9.5 now that we are not
able to directly assign the actuator pole


Problem 3:
Open Loop Poles are \lamda =
   -2.8612
    0.9892
   10.0000
```

```
Controllable since controllability matrix is rank 3 and A is rank 3

Control Gains are K =
  68.0400 + 0.0000i  10.5561 + 0.0000i

Closed Loop Poles are \lamda =
  12.1511 + 0.0000i
  -2.0116 + 1.9966i
  -2.0116 - 1.9966i

Desired Eigen Vectors are v =
   0.2000 + 0.3500i   0.2000 - 0.3500i
  -0.9800 + 0.0700i  -0.9800 - 0.0700i

Achievable Eigen Vectors are v =
   0.1804 + 0.3599i   0.1804 - 0.3599i
  -0.9791 + 0.0790i  -0.9791 - 0.0790i
  -1.8516 +20.7926i  -1.8516 -20.7926i

The actuator pole has moved increasingly positive to 12.15


Problem 4:
Open Loop Poles are \lamda =
    -1
    -2

The poles are negative so the open loop system is stable
Control Gains are K =
    6.5000    2.5000
```

Published with MATLAB® R2022a