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Question 1.

```
clear
```

a)

Find a realization of the transfer function. Verifying asnwers

```
A = [-2 0 0 0;...
      0 -2 0 0;...
      1 0 0 0;...
      0 1 0 0];

 B = [1 0;...
      0 1;...
      0 0;...
      0 0];

 C = [1 1 2 0];

 D = [1 0];

 syms s;
 tf3 = C*inv(s*eye(4) - A)*B + D;
 simplify(tf3);
```

b) Determine if this realization is controllable and/or observable

```
ctrb_AB = rank(ctrb(A,B))
obvs_AC = rank(obsv(A,C))
```

c)

```
A2 = [-2 0; 1 0];
```

```
 B2 = [1;0];
 C2 = [ 1 2; 1 0];
 D2 = [1;0]

simplify(C2*inv(s*eye(2)-A2)*B2 + D2);
ctrb_AB_new = rank(ctrb(A2,B2))
Obvs_AC_new = rank(obsv(A2,C2))
```

```
ctrb_AB =

     4


obvs_AC =

     2


D2 =

     1
     0


ctrb_AB_new =

     2


Obvs_AC_new =

     2
```

Question 3

```
clear
A = [1  0  0;...
     1  1  0;...
     -2 1 1];
B = [2 0 0]';
C = [1 0 1];
```

a) Is this system observable?

```
rank(obsv(A,C));
```

b) Compute a matrix k such that A+kc has the eigen values of -1

```
syms s k1 k2 k3 real;
```

```
K = [k1 k2 k3]';
temp = A+K*C;            % Put this in control cononical form
alpha = charpoly(temp);
Cr = [B temp*B, temp^2*B];
T = Cr*[1 alpha(2) alpha(3); 0 1 alpha(2); 0 0 1];
ACc = simplify(inv(T)*temp*T);

% We need the first row of ACc to equal [-3 -3 -1] IOT move the poles
a = [1 0 1; -4 1 -2; 4 -1 1];
b = [-6 0 -2]';
K = [a \ b];
```

c)

```
f = [-9 -74 -24];

temp = A-B*k1*C;
alpha = charpoly(temp);
Cr = [B temp*B, temp^2*B];
T = Cr*[1 alpha(2) alpha(3); 0 1 alpha(2); 0 0 1];
ACc = simplify(inv(T)*temp*T);
```

Question 4

```
clear

A = [-1 0; 0 -1];
B = eye(2);
C = [-1 1];
D = [2 1];
% A realization is minimal if it is both observable and controllable
ctrb_AB = rank(ctrb(A,B))
obvs_AC = rank(obsv(A,C))
T = [-1 1; 1 1];
A_bar = inv(T)*A*T;
B_bar = inv(T)*B;
C_bar = C*T;
Aoc = A_bar(1,1);
Boc = B_bar(1,:);
Coc = C_bar(1);

syms s
simplify(C*inv(s*eye(2)-A)*B + D)
simplify(Coc*inv(s-Aoc)*Boc + D)
```

```
ctrb_AB =

     2


obvs_AC =
```

```
     1
```

```
ans =

[ 2 - 1/(s + 1), 1/(s + 1) + 1]
```

```
ans =

[ 2 - 1/(s + 1), 1/(s + 1) + 1]
```

Question 5

```
clear
syms a1 a2 a3 a4 c1 c2 c3 c4 b1 b2 b3 b4 real
A = diag([a1,a2,a3,a4]);
C = [c1 c2 c3 c4];
B = [b1 b2 b3 b4]';
```

d)

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

rank(ctrb(A,B))
rank(obsv(A,C))
```

```
ans =

     2
```

```
ans =

     2
```

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