EE324 Control Systems Lab

Problem Sheet 10

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1 Question 1

Code

```
s = poly(0, 's')


T = [1, 2, 3;
    3, 4, 5;
    4, 6, 9]
A = [1, 5, 7;
    2, 0, 4;
    3, 3, 2]
B = [2;
    5;
    7]
C = [3, 1, 4]
D = 34
```

```
T_ = inv(T)
A_ = T_ * A * T
B_ = T_ * B
C_ = C * T

// part A
G = D + C * inv(s * eye(3, 3) - A) * B
G_ = D + C_ * inv(s * eye(3, 3) - A_) * B_
disp(G)
disp(G_)

// part B
disp(spec(A))
disp(roots(G.den))

// part C
G1 = (3 + 4*s + s^2) / (1 + s + s^2)
G2 = (3 + 2*s) / (1 + s + s^2)
ssr1 = tf2ss(G1)
ssr2 = tf2ss(G2)
disp(ssr1)
disp(ssr2)
```

```
                    2      3
-1868 - 1111s - 63s + 34s        8.66442678
--------------------------     -2.83221339 + 0.239954993i
                  2   3        -2.83221339 - 0.239954993i
   -70 - 41s - 3s + s

                    2      3
-1868 - 1111s - 63s + 34s        8.66442678
--------------------------     -2.83221339 + 0.239954993i
                  2   3        -2.83221339 - 0.239954993i
   -70 - 41s - 3s + s
```

Figure 1: Part A: Both G(s) are same, Part B: Poles of G(s) are same as eigenvalues of A

```
!lss  A  B  C  D  X0  dt  !
  -0.692307692  -0.538461538
   1.461538462  -0.307692308
  -1.860521019
   1.240347346
  -1.61245155   2.22045D-16
   1.
   0.
   0.
    []

!lss  A  B  C  D  X0  dt  !
  -0.307692308  -0.538461538
   1.461538462  -0.692307692
  -1.240347346
   1.860521019
  -1.61245155   0.
   0.
   0.
   0.
    []
```

Figure 2: Part C: SSRs of both transfer functions. D is non-zero for the proper G(s), and 0 for the strictly proper one

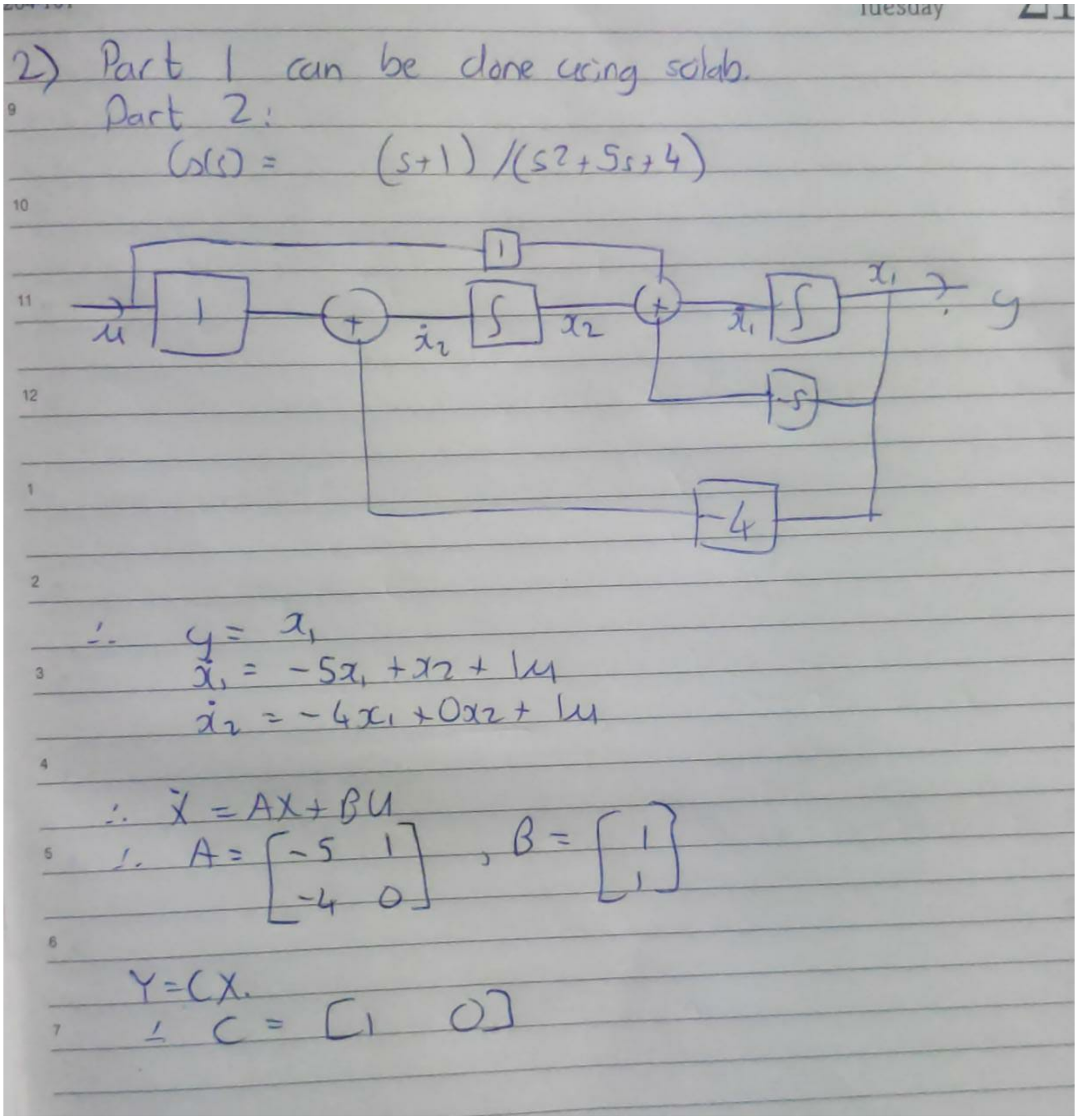
2 Question 2

Code

```
s = poly(0, 's')

G1 = (s + 3) / (4 + 5*s + s^2)

G2 = (s + 1) / (4 + 5*s + s^2)

ssr1 = tf2ss(G1)

ssr2 = tf2ss(G2)

disp(ssr1)

disp(ssr2)
```

```
!lss  A  B  C  D  X0  dt  !
  -1.538461538   0.307692308
   4.307692308  -3.461538462
  -1.109400392
   1.664100589
  -0.901387819   0.
   0.
   0.
   0.
    []

!lss  A  B  C  D  X0  dt  !
  -4.
   1.
   1.
   0.
   0.
    []
```

Figure 3: SSRs given by scilab



2) Part 1 can be done using scilab.

Part 2:

$G(s) = (s+1)/(s^2+5s+4)$

$\therefore\ y = x_1$

$\dot{x}_1 = -5x_1 + x_2 + 1u$

$\dot{x}_2 = -4x_1 + 0x_2 + 1u$

$\therefore\ \dot{X} = AX + BU$

$\therefore\ A = \begin{bmatrix} -5 & 1 \\ -4 & 0 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$

$Y = CX.$

$\therefore\ C = [1 \quad 0]$

Figure 4: Manually calculated SSR for part 2

3 Question 3

3.1 Code

```
s = poly(0, 's')


A = [1, 0, 0;
    0, 2, 0;
    0, 0, 3]
B = [2;
    5;
    7]
B_ = [0;
    5;
    7]
C = [3, 1, 4]
C_ = [3, 0, 4]


G1 = C * inv(s * eye(3, 3) - A) * B
G2 = C * inv(s * eye(3, 3) - A) * B_
G3 = C_ * inv(s * eye(3, 3) - A) * B
disp(roots(G1.den))
disp(roots(G2.den))
disp(roots(G3.den))
```

```
3.
2.
1.

3.
2.

3.
1.
```

Figure 5: The corresponding poles are cancelled when an entry of B/C is made zero

4 Question 4

Code

```
s = poly(0, 's')


A = [2, 10, 0;
    0, 2, 10;
    0, 0, 1]
B = [1;
    1;
    1]
C = [1/100, 1/-10, 1/1] .* [2, -1, -1]


G1 = C * inv(s * eye(3, 3) - A) * B
disp(inv(s * eye(3, 3) - A) * B)
disp(simp(G1))
disp(roots(G1.den))
```

The pole at 1 has been cancelled. I think it is best to verbally explain the method used to arrive at this A, B, C.

```
                  2
  92 + 7s + s
-----------------
               2   3
-4 + 8s - 5s + s

  9 + s
-----------
          2
2 - 3s + s

  1
-------

-1 + s


3.96 - 0.88s
-------------
           2
 4 - 4s + s

1.99999997
2.00000003
```

Figure 6: Value of X, Y = CX, poles of the transfer function