Assignment 4
State Space

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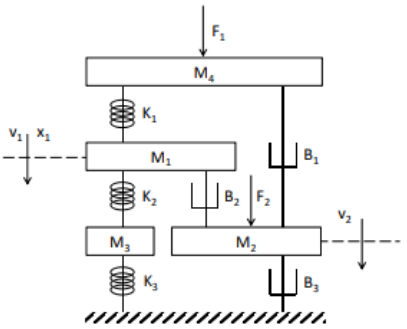
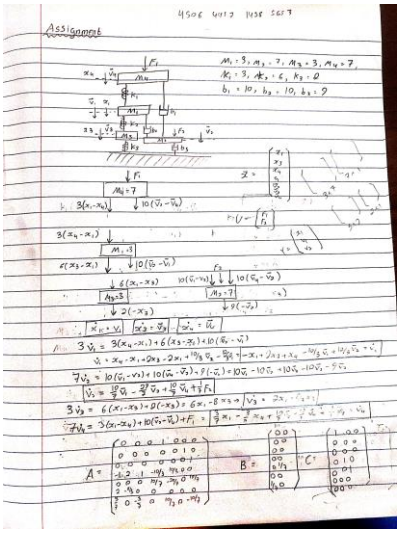
1. Compute A, B, C, D matrixes for the system

CONSTANTS:

- M1 = 3
- M2 = 7
- M3 = 3
- M4 = 7
- k1 = 3
- k2 = 6
- k3 = 2
- b1 = 10
- b2 = 10
- b3 = 9



1. Compute A, B, C, D matrixes for the system



Work

A =

	x1	x2	x3	x4	x5	x6	x7
x1	0	0	0	1	0	0	0
x2	0	0	0	0	0	1	0
x3	0	0	0	0	0	0	1
x4	-1	2	1	-3.333	3.333	0	0
x5	0	0	0	1.429	-4.143	0	1.429
x6	2	-2.667	0	0	0	0	0
x7	0.4286	0	-0.4286	0	1.429	0	-1.429

B =

	u1	u2
x1	0	0
x2	0	0
x3	0	0
x4	0	0
x5	0	0.1429
x6	0	0
x7	0.1429	0

C =

	x1	x2	x3	x4	x5	x6	x7
y1	1	0	0	0	0	0	0
y2	0	0	0	1	0	0	0
y3	0	0	0	0	1	0	0

D =

	u1	u2
y1	0	0
y2	0	0
y3	0	0

Matrices

2. Use Matlab to compute the state transition matrix (STM) – How to get STM

Matlab script to create state transition Matrix (couldn't fit full STM)

$\Phi(s) = \text{Inverse}([sI - A])$

```
>> syms s
>> stm = inv(s * eye(size(A)) - A)

stm =

[ (441*s^6 + 3927*s^5 + 9165*s^4 + 14585*s^3 + 22114*s^2 + 10968*s + 2160)/(441*s^7 + 3927*s^6 + 9
[                         (6*(147*s^4 + 1309*s^3 + 2663*s^2 + 1371*s + 270))/(441*s^7 + 3927*s^6 + 9
[                           (3*(63*s^4 + 471*s^3 + 438*s^2 + 1256*s + 1920))/(441*s^7 + 3927*s^6 + 9
[            (3*(- 147*s^5 - 819*s^4 - 74*s^3 + 1092*s^2 + 1812*s + 1044))/(441*s^7 + 3927*s^6 + 9
[                                      (120*(- 3*s^4 + 13*s^2 + 30*s + 9))/(441*s^7 + 3927*s^6 + 9
[                    (6*(147*s^5 + 1309*s^4 + 2663*s^3 + 1371*s^2 + 270*s))/(441*s^7 + 3927*s^6 + 9
[                      (3*(63*s^5 + 471*s^4 + 438*s^3 + 1256*s^2 + 1920*s))/(441*s^7 + 3927*s^6 + 9
```

2. Use Matlab to compute the state transition matrix – Show STM has same roots as the State Space Model

STM had: 441*s^7 + 3927*s^6 + 9606*s^5 + 17042*s^4 + 22336*s^3 + 7692*s^2 - 3276*s – 3132

In the denominator

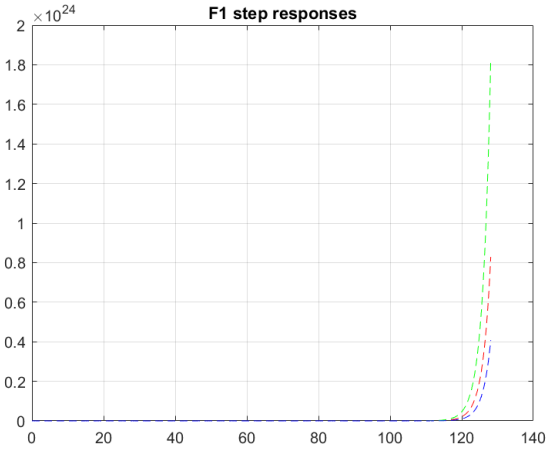
```
+ 2160)/(441*s^7 + 3927*s^6 + 9606*s^5 + 17042*s^4 + 22336*s^3 + 7692*s^2 - 3276*s - 3132),
+ 270))/(441*s^7 + 3927*s^6 + 9606*s^5 + 17042*s^4 + 22336*s^3 + 7692*s^2 - 3276*s - 3132),
 1920))/(441*s^7 + 3927*s^6 + 9606*s^5 + 17042*s^4 + 22336*s^3 + 7692*s^2 - 3276*s - 3132),
 1044))/(441*s^7 + 3927*s^6 + 9606*s^5 + 17042*s^4 + 22336*s^3 + 7692*s^2 - 3276*s - 3132),
s + 9))/(441*s^7 + 3927*s^6 + 9606*s^5 + 17042*s^4 + 22336*s^3 + 7692*s^2 - 3276*s - 3132),
270*s))/(441*s^7 + 3927*s^6 + 9606*s^5 + 17042*s^4 + 22336*s^3 + 7692*s^2 - 3276*s - 3132),
920*s))/(441*s^7 + 3927*s^6 + 9606*s^5 + 17042*s^4 + 22336*s^3 + 7692*s^2 - 3276*s - 3132),
```

2. Use Matlab to compute the state transition matrix – Show STM has same roots as the State Space Model

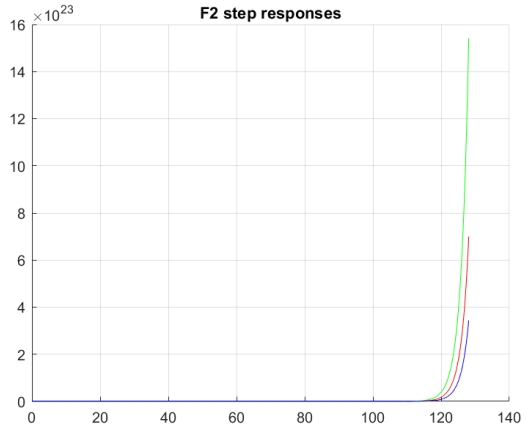
By taking pole of State Space Model and Roots of the denominator, we observe That they are the same.

```
>> pole(sys)

ans =

  -6.1951 + 0.0000i
  -0.1532 + 1.7774i
  -0.1532 - 1.7774i
   0.4539 + 0.0000i
  -1.7689 + 0.0000i
  -0.5441 + 0.3906i
  -0.5441 - 0.3906i

>> roots([441 3927 9606 17042 22336 7692 -3276 -3132])

ans =

  -6.1951 + 0.0000i
  -0.1532 + 1.7774i
  -0.1532 - 1.7774i
  -1.7689 + 0.0000i
   0.4539 + 0.0000i
  -0.5441 + 0.3906i
  -0.5441 - 0.3906i
```

3. Plot the unit step response (F1 only) for all 3 outputs on the same graph



3. Plot the unit step response (F2 only) for all 3 outputs on the same graph



3. Plot total step response (F1 + F2) for x1 (first output)