ĐẠI HỌC QUỐC GIA HÀ NỘI

TRƯỜNG ĐẠI HỌC KHOA HỌC TỰ NHIÊN

KHOA TOÁN – CƠ TIN HỌC

TIỂU LUẬN CUỐI KỲ
MỘT SỐ VẤN ĐỀ CHỌN LỌC TRONG TÍNH TOÁN KHOA HỌC

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(Chương trình đào tạo chuẩn)

Hà Nội - 2021

Câu 1:

Lý thuyết :

$$(s^3+2s-9)(s-1)$$
$$=s^3-s^2+2s^2-9s+9$$
$$=s^3+s^2-11s+9$$

$$G(s)=\begin{bmatrix} \dfrac{s}{(s-1)^2} & \dfrac{s}{s-1} \\ \dfrac{s^2+2s-9}{(s-1)(s+3)} & \dfrac{s+4}{s+3} \end{bmatrix}\begin{bmatrix} \dfrac{s}{s^2-2s+1} & \dfrac{s}{s-1} \\ \dfrac{s^2+2s-9}{s^2+2s-3} & \dfrac{s+4}{s+3} \end{bmatrix}$$

$$D=\lim_{x\to\infty} G(s)=\begin{bmatrix} 0 & 1 \\ 1 & 1 \end{bmatrix}$$

$$\widehat{G}(s)-D=\begin{bmatrix} \dfrac{s}{(s-1)^2}-0 & \dfrac{s}{s-1}-1 \\ \dfrac{s^2+2s-9}{(s-1)(s+3)}-1 & \dfrac{s+4}{s+3}-1 \end{bmatrix}$$

$$=\begin{bmatrix} \dfrac{s}{(s-1)^2} & \dfrac{s}{s-1} \\ \dfrac{-6}{(s-1)(s+3)} & \dfrac{1}{s+3} \end{bmatrix}=\frac{1}{(s-1)^2(s+3)}\begin{bmatrix} s(s+3) & (s-1)(s+3) \\ -6(s-1) & (s-1)^2 \end{bmatrix}$$

Viết lại:

$$G(s)=(s-1)^2(s+3)=s^3+1s^2-5s+3$$

r (bậc cao nhất của mẫu số) = 3

$$N(s) = N_1 s^2 + N_2 s + N_3$$

$$= \begin{bmatrix} s(s+3) & (s-1)(s+3) \\ -6(s-1) & (s-1)^2 \end{bmatrix} = \begin{bmatrix} s^2+3s & s^2+2s-3 \\ -6s+6 & s^2-2s+1 \end{bmatrix}$$

$$= \underbrace{\begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}}_{N_1} s^2 + \underbrace{\begin{bmatrix} 3 & 2 \\ -6 & -2 \end{bmatrix}}_{N_2} s + \underbrace{\begin{bmatrix} 0 & -3 \\ 6 & 1 \end{bmatrix}}_{N_3}$$

- Dạng chính tắc điều khiển được:

  Số chiều là: n = r x p = 2 x 3 = 6

Hệ không gian trạng thái

$$\begin{cases} \dot{x} = Ax + Bu \\ y = Cx + Du \end{cases}$$

$$A = \begin{bmatrix} -\alpha_1.I_p & -\alpha_2.I_p & -\alpha_3.I_p \\ I_p & O_p & 0 \\ 0 & I_p & O_p \end{bmatrix}$$

$$= \begin{bmatrix} -1\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} & 5\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} & -3\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \\ \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \\ \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} & \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \end{bmatrix} = \begin{bmatrix} \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix} & \begin{bmatrix} 5 & 0 \\ 0 & 5 \end{bmatrix} & \begin{bmatrix} -3 & 0 \\ 0 & -3 \end{bmatrix} \\ \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \\ \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} & \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \end{bmatrix}$$

$$= \begin{bmatrix} -1 & 0 & 5 & 0 & -3 & 0 \\ 0 & -1 & 0 & 5 & 0 & -3 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

$$B = \begin{bmatrix} I_p \\ O_p \\ O_p \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 3 & 2 & 0 & -3 \\ 0 & 1 & -6 & -2 & 6 & 1 \end{bmatrix}$$

$$C = \begin{bmatrix} N_1 & N_2 & N_3 \end{bmatrix}$$

$$D = \begin{bmatrix} 0 & 1 \\ 1 & 1 \end{bmatrix}$$

❖ Dạng chính tắc quan sát được

Số chiều là: n = r x q = 3 x 2 = 6

Hệ không gian trạng thái

$$\begin{cases} \dot{x} = Ax + Bu \\ y = Cx + Du \end{cases}$$

$$A = \begin{bmatrix} -\alpha_1 I_p & I_q & 0 \\ -\alpha_2 I_p & 0_q & I_q \\ -\alpha_3 I_p & 0 & 0_q \end{bmatrix}$$

$$= \begin{bmatrix} -1\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} & \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \\ 5\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} & \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \\ -3\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \end{bmatrix} = \begin{bmatrix} \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix} & \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \\ \begin{bmatrix} 5 & 0 \\ 0 & 5 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} & \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \\ \begin{bmatrix} -3 & 0 \\ 0 & -3 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} & \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix} \end{bmatrix}$$

$$= \begin{bmatrix} -1 & 0 & 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 & 0 & 0 \\ 5 & 0 & 0 & 0 & 1 & 0 \\ 0 & 5 & 0 & 0 & 0 & 1 \\ -3 & 0 & 0 & 0 & 0 & 0 \\ 0 & -3 & 0 & 0 & 0 & 0 \end{bmatrix}$$

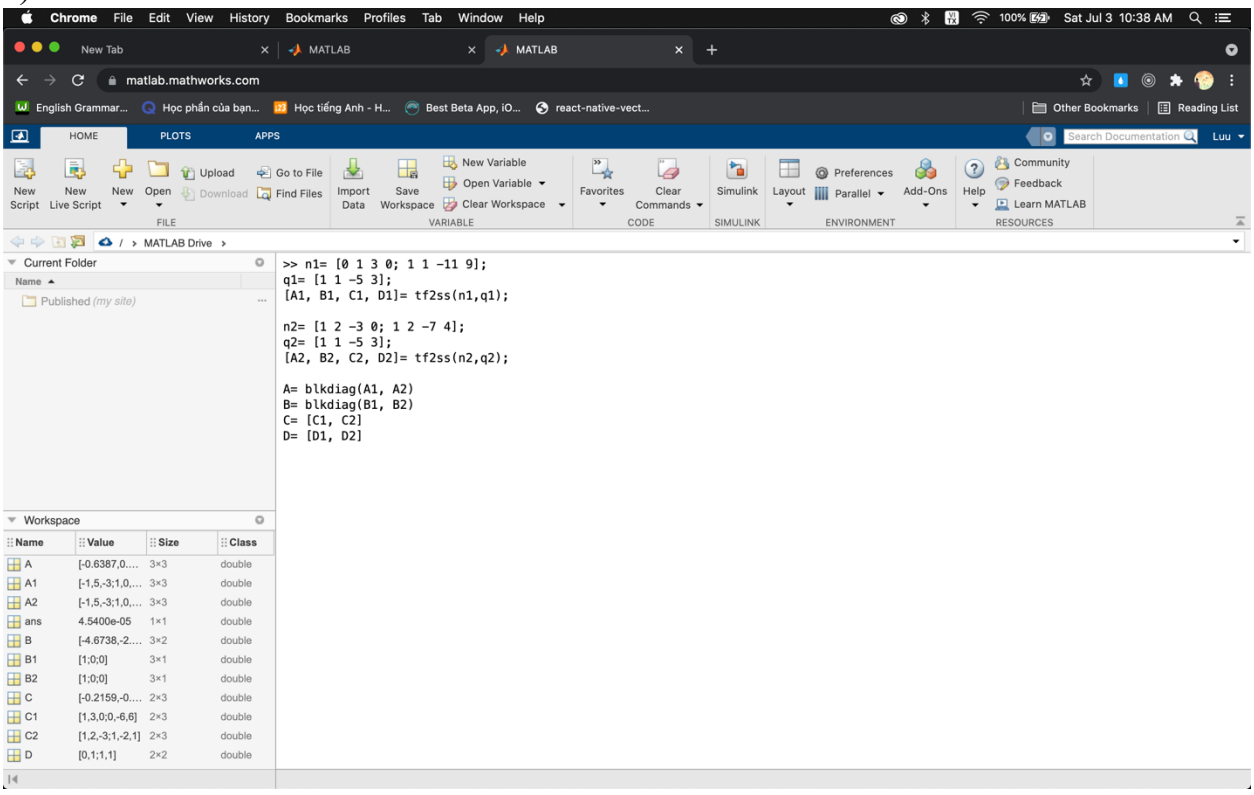
$$B = \begin{bmatrix} N_1 \\ N_2 \\ N_3 \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 0 & 1 \\ 3 & 2 \\ -6 & 2 \\ 6 & -3 \\ 6 & 1 \end{bmatrix}$$

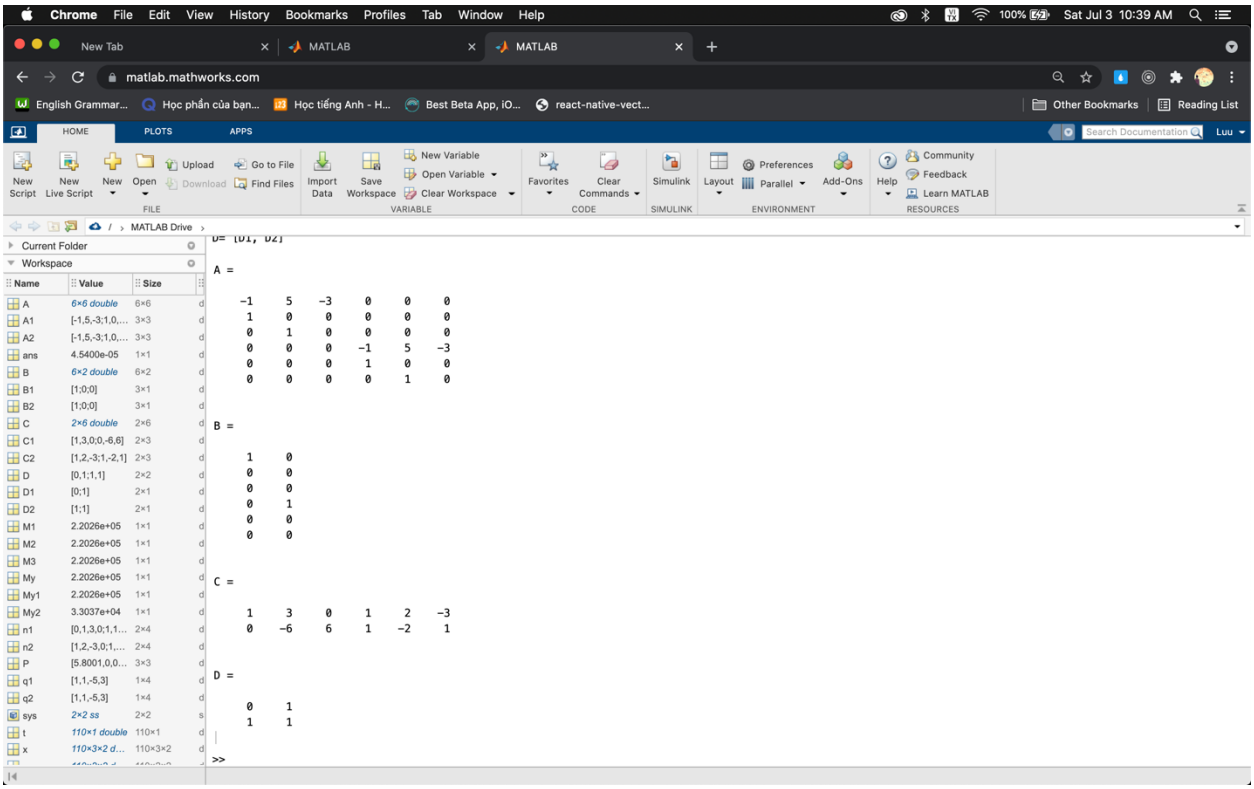
$$C = \begin{bmatrix} I_q & 0_q & 0 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$D = \begin{bmatrix} 0 & 1 \\ 1 & 1 \end{bmatrix}$$

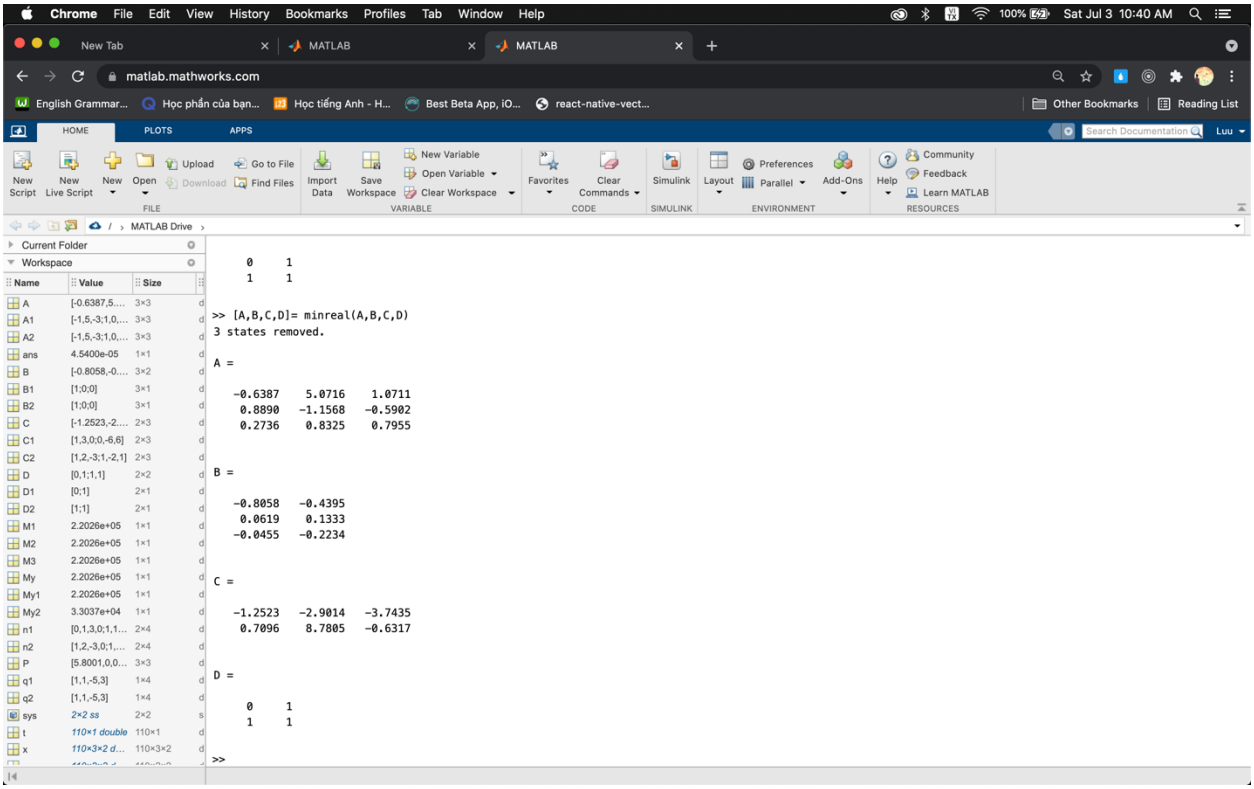
Thực hành :

a)

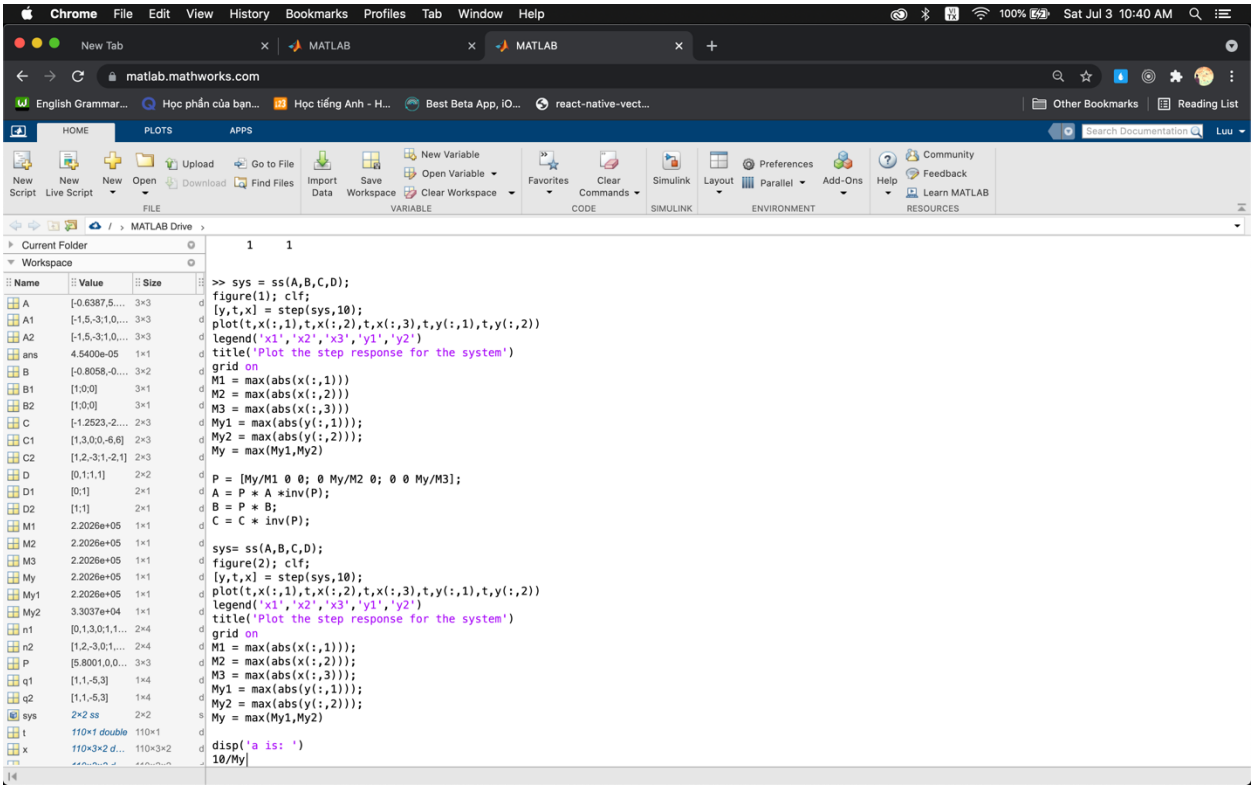



D= [D1, D2]
A =
-1 5 -3 0 0 0
1 0 0 0 0 0
0 1 0 0 0 0
0 0 0 -1 5 -3
0 0 0 1 0 0
0 0 0 0 1 0
B =
1 0
0 0
0 0
0 1
0 0
0 0
C =
1 3 0 1 2 -3
0 -6 6 1 -2 1
D =
0 1
1 1
>>

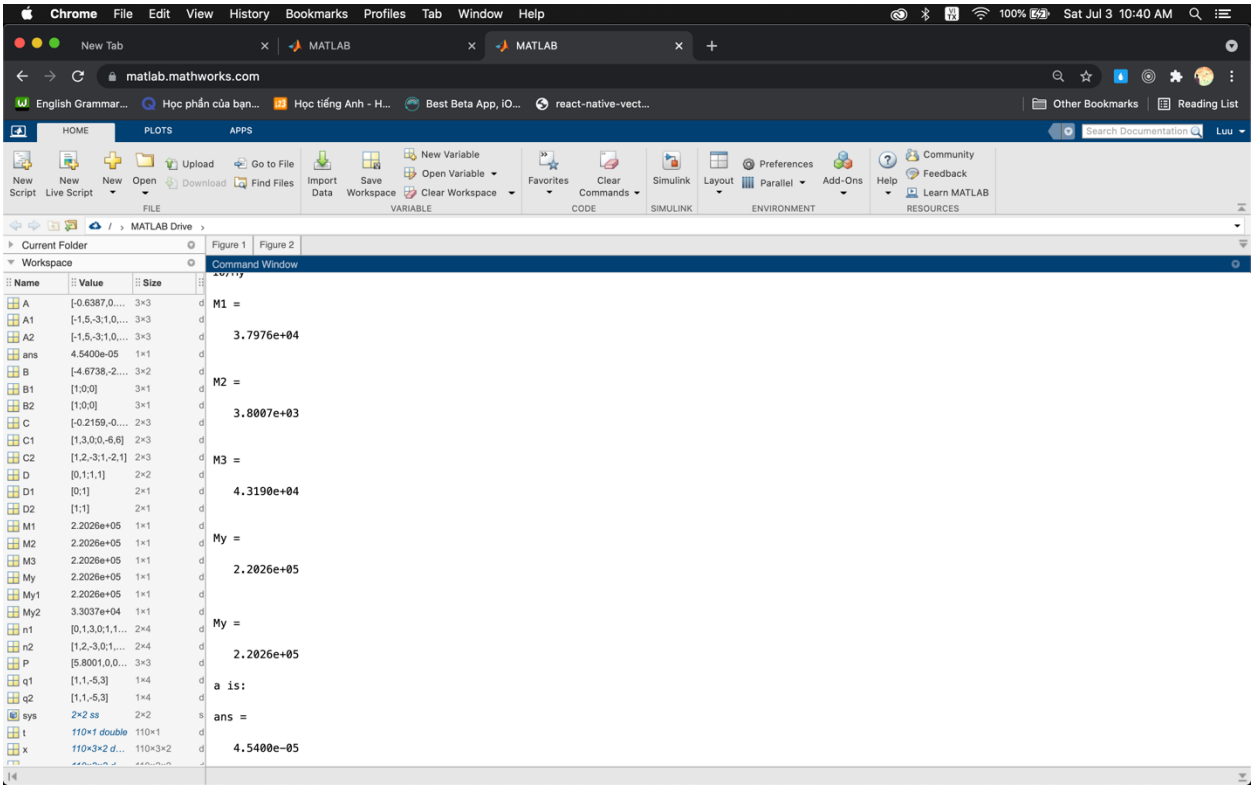
b)


0 1
1 1
>> [A,B,C,D]= minreal(A,B,C,D)
3 states removed.
A =
-0.6387 5.0716 1.0711
0.8890 -1.1568 -0.5902
0.2736 0.8325 0.7955
B =
-0.8058 -0.4395
0.0619 0.1333
-0.0455 -0.2234
C =
-1.2523 -2.9014 -3.7435
0.7096 8.7805 -0.6317
D =
0 1
1 1
>>

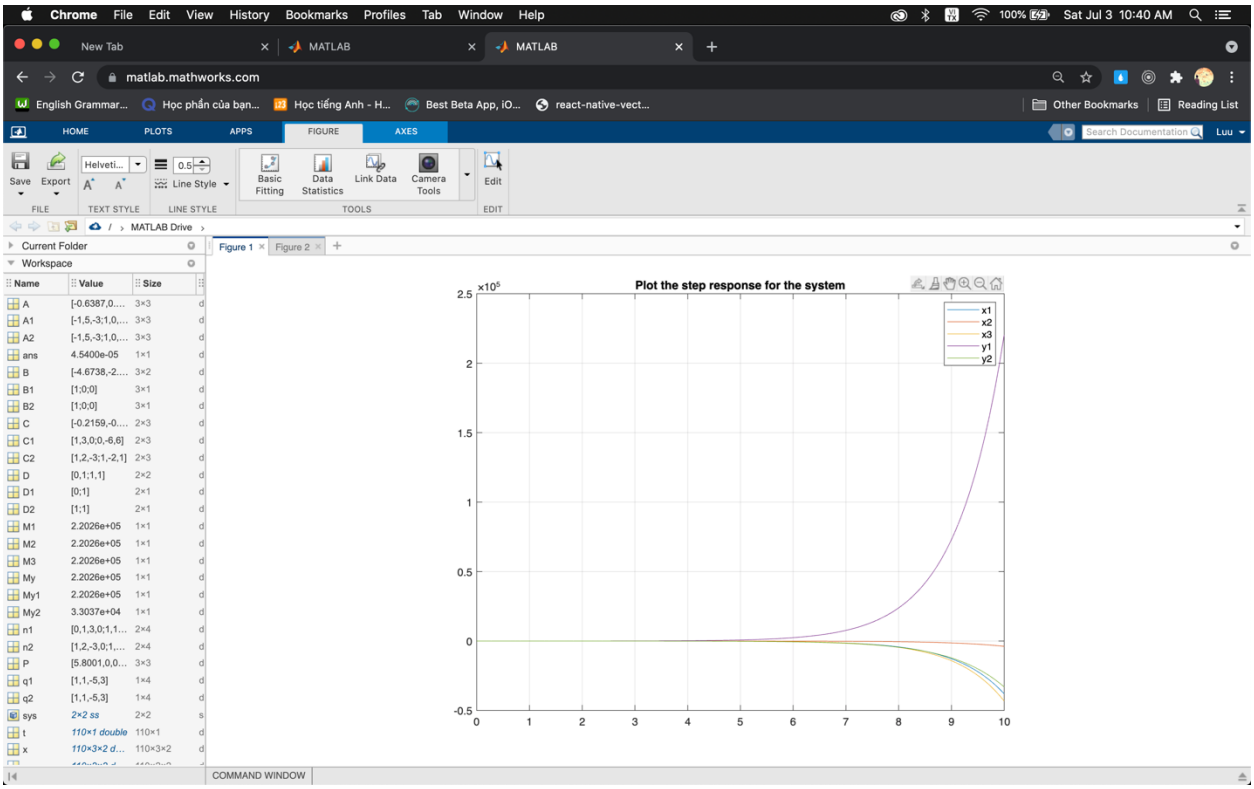
c,d)

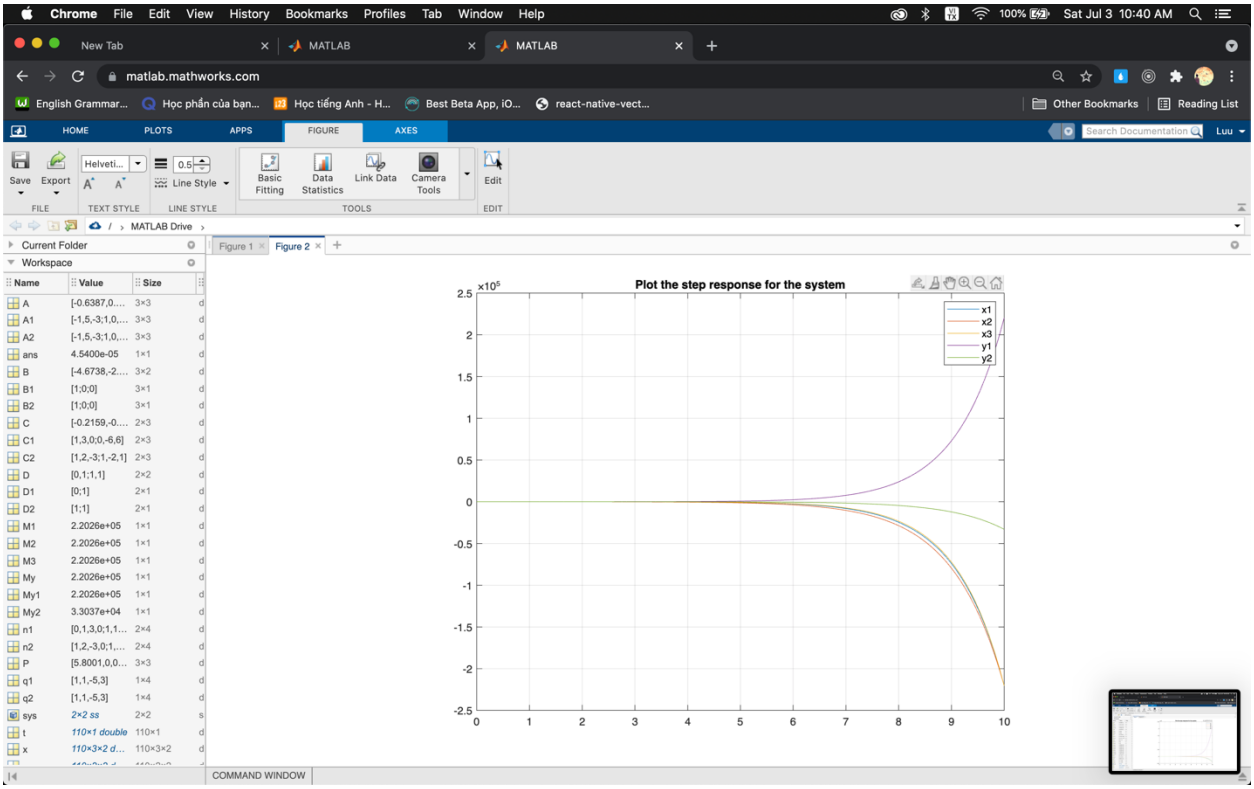


```
    1     1


>> sys = ss(A,B,C,D);
figure(1); clf;
[y,t,x] = step(sys,10);
plot(t,x(:,1),t,x(:,2),t,x(:,3),t,y(:,1),t,y(:,2))
legend('x1','x2','x3','y1','y2')
title('Plot the step response for the system')
grid on
M1 = max(abs(x(:,1)))
M2 = max(abs(x(:,2)))
M3 = max(abs(x(:,3)))
My1 = max(abs(y(:,1)));
My2 = max(abs(y(:,2)));
My = max(My1,My2)

P = [My/M1 0 0; 0 My/M2 0; 0 0 My/M3];
A = P * A *inv(P);
B = P * B;
C = C * inv(P);

sys= ss(A,B,C,D);
figure(2); clf;
[y,t,x] = step(sys,10);
plot(t,x(:,1),t,x(:,2),t,x(:,3),t,y(:,1),t,y(:,2))
legend('x1','x2','x3','y1','y2')
title('Plot the step response for the system')
grid on
M1 = max(abs(x(:,1)));
M2 = max(abs(x(:,2)));
M3 = max(abs(x(:,3)));
My1 = max(abs(y(:,1)));
My2 = max(abs(y(:,2)));
My = max(My1,My2)

disp('a is: ')
10/My
```



```
M1 =

   3.7976e+04


M2 =

   3.8007e+03


M3 =

   4.3190e+04


My =

   2.2026e+05


My =

   2.2026e+05

a is:

ans =

   4.5400e-05
```


Plot the step response for the system
x1
x2
x3
y1
y2
COMMAND WINDOW


Plot the step response for the system
x1
x2
x3
y1
y2
COMMAND WINDOW

Câu 2:

a) $X = [X_1 \quad X_2 \quad X_3] = [\theta \quad \dot{\theta} \quad i]$

Vậy

$$\dot{X}_1 = \dot{\theta} = X_2$$

$$\dot{X}_2 = \ddot{\theta} = \frac{NK_m}{J_e} X_3 - \frac{T_d(t)}{J_e}$$

$$\dot{X}_3 = \frac{di}{dt} = \frac{-NK_m}{L} X_2 - \frac{R}{L} X_3 + \frac{1}{L} v(t)$$

Hệ phương trình:

$$\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & \frac{NK_m}{J_e} \\ 0 & \frac{-NK_m}{L} & \frac{-R}{L} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ \frac{-1}{J_e} & 0 \\ 0 & \frac{1}{L} \end{bmatrix} \begin{bmatrix} T_d(t) \\ v(t) \end{bmatrix}$$

$$\Leftrightarrow \dot{X} = AX(t) + BU(t)$$

b)

K_m = 0, 05 Nm/A, R = 1, 2 Ω, L = 0, 05 H, J_m = 0, 0008 kg/m2, J = 0, 02 kg/m^2 và N = 12.

$J_e = J + N \times J_m = 0.02 + 12 \times 0.0008 = 0.0296$

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & \frac{12 \times 0,05}{0,05} \\ 0 & \frac{-12 \times 0,05}{0,05} & \frac{-1.2}{0,05} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ \frac{-1}{0.0296} & 0 \\ 0 & \frac{1}{0,05} \end{bmatrix} \begin{bmatrix} T_d(t) \\ v(t) \end{bmatrix}$$

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 12 \\ 0 & -12 & -24 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ \frac{-1250}{37} & 0 \\ 0 & 20 \end{bmatrix} \begin{bmatrix} T_d(t) \\ v(t) \end{bmatrix}$$

Vậy A = $\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 12 \\ 0 & -12 & -24 \end{bmatrix}$, B = $\begin{bmatrix} 0 & 0 \\ \frac{-1250}{37} & 0 \\ 0 & 20 \end{bmatrix}$, C = [1 0 0], D = 0

Bai2.m | b1.m | Bai1new.m | exp1234.m

```
%Bai2 b

clear all; close all; clc
A=[0 1 0;0 0 12;0 -12 -24];
B=[ 0 0;-1250/37 0;0 20 ];
C=[1 0 0 ;0 0 0];
D=[0 0;0 0 ];

%he khong gian trang thai
[N1,D1]=ss2tf(A,B,C,D,1);
% khong diem va cuc
[Z1,P1,K1] = tf2zp(N1,D1)
```

$$N1 = \begin{bmatrix} 0 & 0 & -33.7838 & -810.8108 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$$D1 = [1 \quad 24 \quad 144 \quad 0]$$

$D1 = [1 \quad 24 \quad 144 \quad 0]$

Hàm truyền trong bài:
Số chiều của u 2x1
Số chiều của x là 3x1
Số chiều của y là 1x1

Vậy hàm truyền là $\hat{g}_{yu}(s) = \frac{0\times s^2+(-33.7808)\times s+(-810.8108)\times s^0}{1\times s^3+24\times s^2+144\times s^1+0\times s^0} = \frac{-33.7808s-810.8108}{s^3+24s^2+144s}$