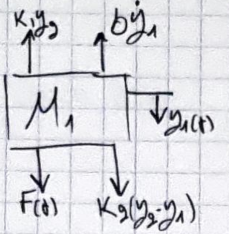
310094059 ניר שניידר

בקרה - תרגיל 2

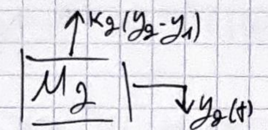


$$M_1\ddot{y}_1 = F(t) + K_2(y_2-y_1) - K_1y_1 - b\dot{y}_1$$

$$\dot{y}_1 = V_1 = 0 + \frac{1}{M_1}\int_{t_0}^{t} F(t) - y_1(K_1+K_2) - b\dot{y}_1 + K_2y_2\,d\tau =$$

$$= \frac{1}{M_2}\int_{t_0}^{\tau} F(t) - y_1(K_1+K_2) + K_2y_2\,d\tau - \frac{b}{M_1}(y_1-y_{10})$$

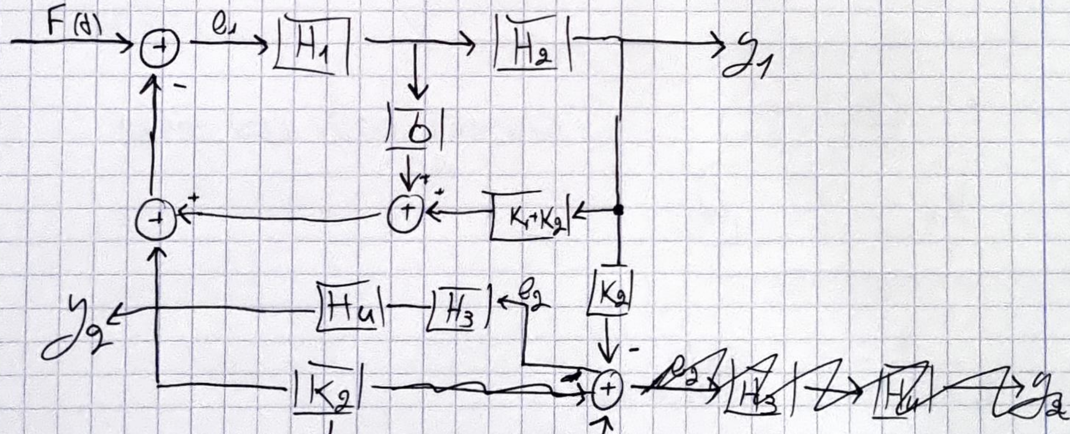
$$y_1 = y_{10} + \int_{t_0}^{t} V_1\,d\tau$$



$$M_2\ddot{y}_2 = K_2(y_2-y_1)$$

$$\dot{y}_2 = V_2 = 0 + \int_{t_0}^{t} \frac{K}{M_2}(y_2-y_1)\,d\tau$$

$$y_2 = y_{20} + \int_{t_0}^{t} V_2\,d\tau$$



$e_1 = F(t) - y_1(K_1+K_2) - b\dot{y}_1 + K_2y_2$, $e_2 = K_2y_2 - K_2y_1$

$H_1 e = \frac{1}{M_1}\int_{t_0}^{t} e\,d\tau$, $H_2 z = y_{10} + \int_{t_0}^{t} z\,d\tau$

$H_3 e = \frac{1}{M_2}\int_{t_0}^{t} e\,d\tau$, $H_4 z = y_{20} + \int_{t_0}^{t} z\,d\tau$

$$T(s) = \frac{Y_2(s)}{F(s)}$$

אחרי העברה לפלס:

$$M_1 s^2 Y_1(s) = F(s) - Y_1(s)(K_1+K_2) - bsY_1(s) + K_2 Y_2(s)$$

$$M_2 s^2 Y_2(s) = K_2 Y_2(s) - K_2 Y_1(s)$$

$$Y_1(s) = Y_2(s)\left(1 - \frac{1}{K_2} M_2 s^2\right)$$

$$\Rightarrow F(s) = Y_1(s)\left(M_1 s^2 + bs + (K_1+K_2)\right) - Y_2(s)K_2 = \left(1-\frac{1}{K_2}M_2 s^2\right)Y_2(s)\left(M_1 s^2 + bs + (K_1+K_2)\right) - Y_2(s)K_2 =$$

$$= Y_2(s)\left[-\frac{1}{K_2}\left(M_1 M_2 s^4 + bM_2 s^3 + M_2(K_1+K_2)s^2\right) + M_1 s^2 + bs + K_1 + K_2\right]$$

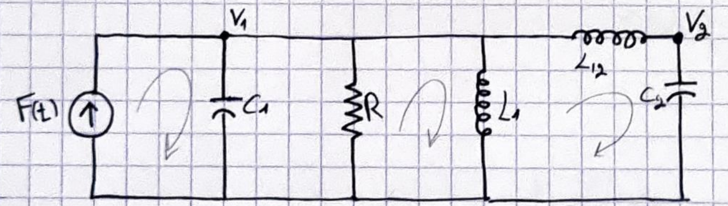
$$T(s) = \frac{Y_2(s)}{F(s)} = \frac{1}{-\frac{M_1M_2}{K_2}s^4 - \frac{bM_2}{K_2}s^3 + \left(M_1 - \frac{M_2}{K_2}(K_1+K_2)\right)s^2 + bs + K_1 + K_2}$$

עבור ערך פרמטרים 1 נקבל:

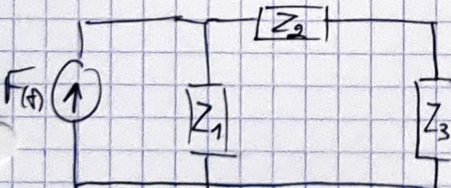
$$T(s) = \frac{1}{-s^4 - s^3 - s^2 + s + 2}$$

---

4)



ראשית נבצע המרה לאימפדנסים:



$$Z_1 = \frac{1}{\frac{1}{R} + \frac{1}{sL_2} + sC_1} = \frac{sRL_2}{s^2 C_1 L_1 R + sL_2 + R}$$

$$Z_2 = sL_{21} \quad , \quad Z_3 = \frac{1}{sL_2}$$

$$Z_{23} = sL_{12} + \frac{1}{sC_2}$$

$$I_{23} = F(s)\,\frac{Z_1}{Z_{23} + Z_1}$$

$$V_2 = V_{Z_3} = I_{Z_3} \cdot Z_3 = F(s) \cdot \frac{Z_3 Z_1}{Z_{23} + Z_1}$$

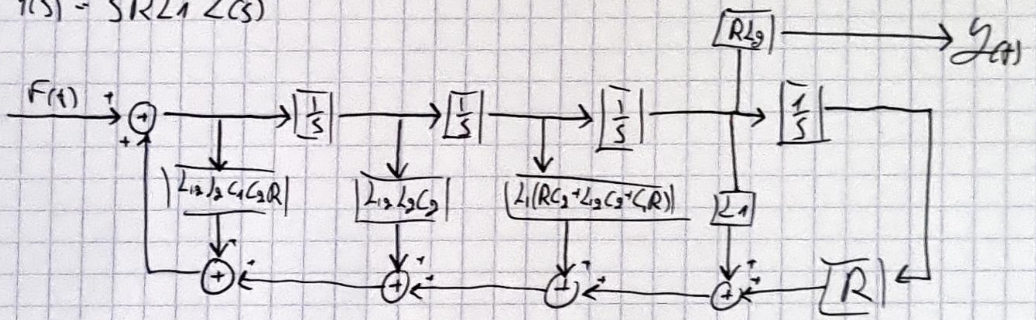
$$T(s)=\frac{V_2(s)}{F(s)} \Rightarrow \frac{Z_2 Z_1}{Z_1+Z_{23}} = \frac{\frac{1}{sC_2}\cdot\frac{sRL_1}{s^2C_1L_1R+sL_1+R}}{\frac{sRL_1}{s^2C_1L_1R+sL_1R}+sL_{12}+\frac{1}{sC_2}} = \dots =$$

$$= \frac{sRL_1}{s^2RL_1C_2+(s^2L_{12}C_2+1)(s^2C_1L_1R+sL_1+R)} = \cancel{L_{12}L_1C_1C_2R)s^4+(L_{12}L_2C_2)s^3}$$

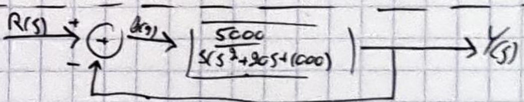
$$= \frac{sRL_1}{(L_{12}L_1C_1C_2R)s^4+(L_{12}L_2C_2)s^3+(RL_1C_2+L_1L_{12}C_2+L_1C_1R)s^2+L_1s+R}$$

$$T(s)=\frac{X(s)}{Y(s)} \quad Z(s) \triangleq X(s)\cdot\frac{1}{\sim\sim}$$

$$Y(s)=sRL_1Z(s)$$



(6)



$$T(s)=\frac{Y(s)}{R(s)}$$

$$Y(s)=e(s)H(s) \quad , \quad e(s)=R(s)-Y(s)$$

$$\frac{H}{1+H} = \frac{\frac{5000}{\sim}}{1+\frac{5000}{\sim}} = \frac{5000}{s^3+20s^2+1000s+5000}$$

לאחר פיתוח המכנה נמצא כי הקטבים הינם $0, -10\pm30j$

$$R(s)=\frac{1}{s}$$

$$Y(s)=\frac{1}{s}\cdot\frac{5000}{s^3+20s^2+1000s+5000} = \left(\begin{matrix}\text{פירוק}\\ \text{שברים}\end{matrix}\right) =$$

$$= \frac{0.098+0.09i}{s+7.28-29.45i} + \frac{0.098-0.09i}{s+7.28+29.45i} - \frac{1.05}{s+5.42} + \frac{1}{s}$$

הקוטב הימני ביותר בעל השפעה (ס״ע). כלומר המע׳ סיבתית (משמכמה בקוטב) לכן הקוטב הימני ביותר קובע - ... ימני.

Contents

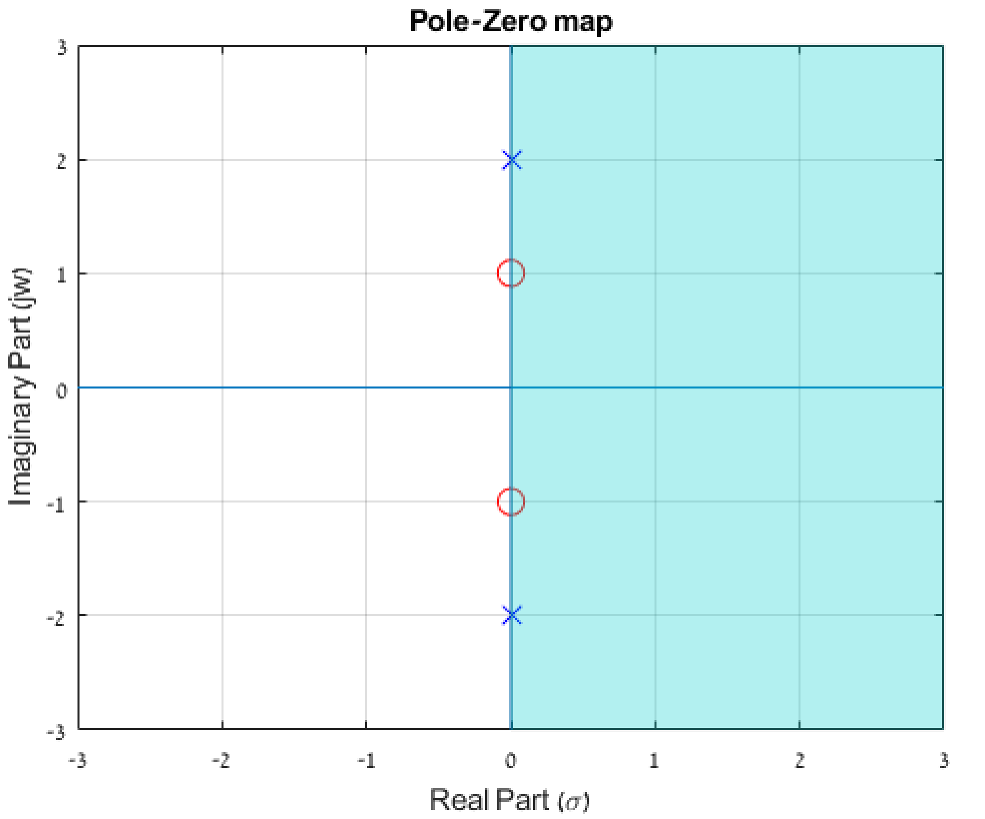
Students ID's

```
ID = 316098052;
disp(ID)
```

```
316098052
```

1 Pole-Zero Plot

```
pzplot2([1 0 1],[1 0 4 ])
```



2 Solve the following problems

2.1

```
Y = [1 -1 6];
X = [0  1 1];
tf(X,Y)
step(tf(X,Y));
pzplot2(X,Y);
```

```
ans =

     s + 1
  -----------
  s^2 - s + 6

Continuous-time transfer function.
```

2.2

```
Y = [3 -2 6];
X = [2 1 -1];
tf(X,Y)
step(tf(X,Y));
pzplot2(X,Y);
```

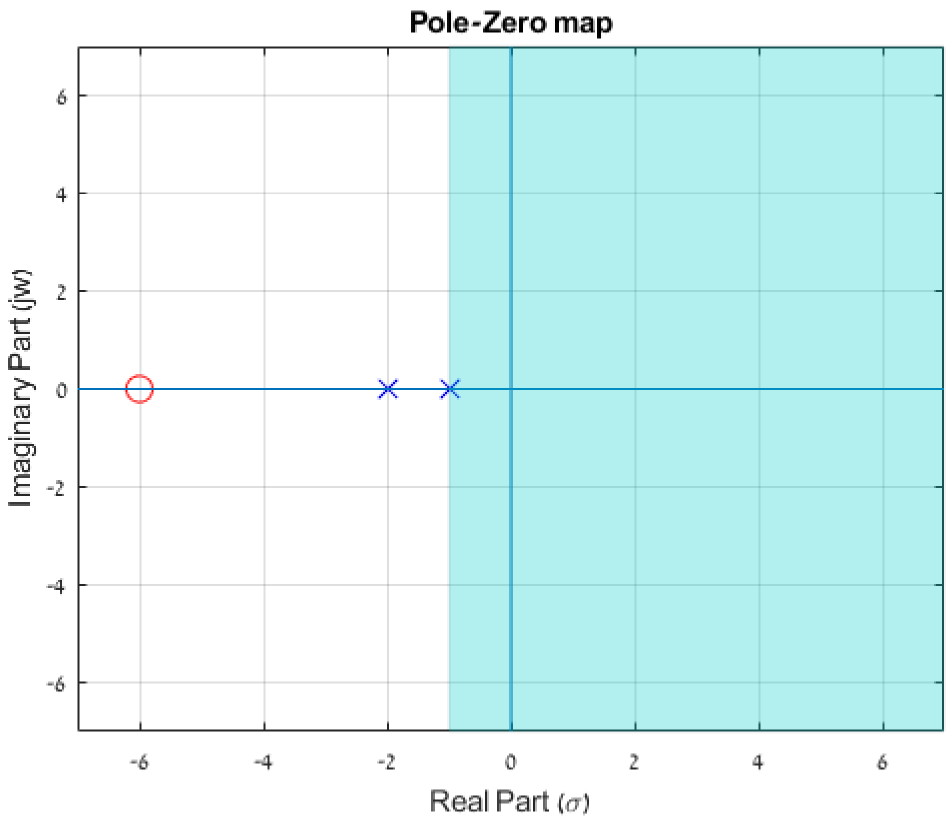
2.3

```
Y = [1 3 2];
X = [0 1 6];
tf(X,Y)
step(tf(X,Y));
pzplot2(X,Y);
```

```
ans =

      s + 6
  -------------
  s^2 + 3 s + 2

Continuous-time transfer function.
```



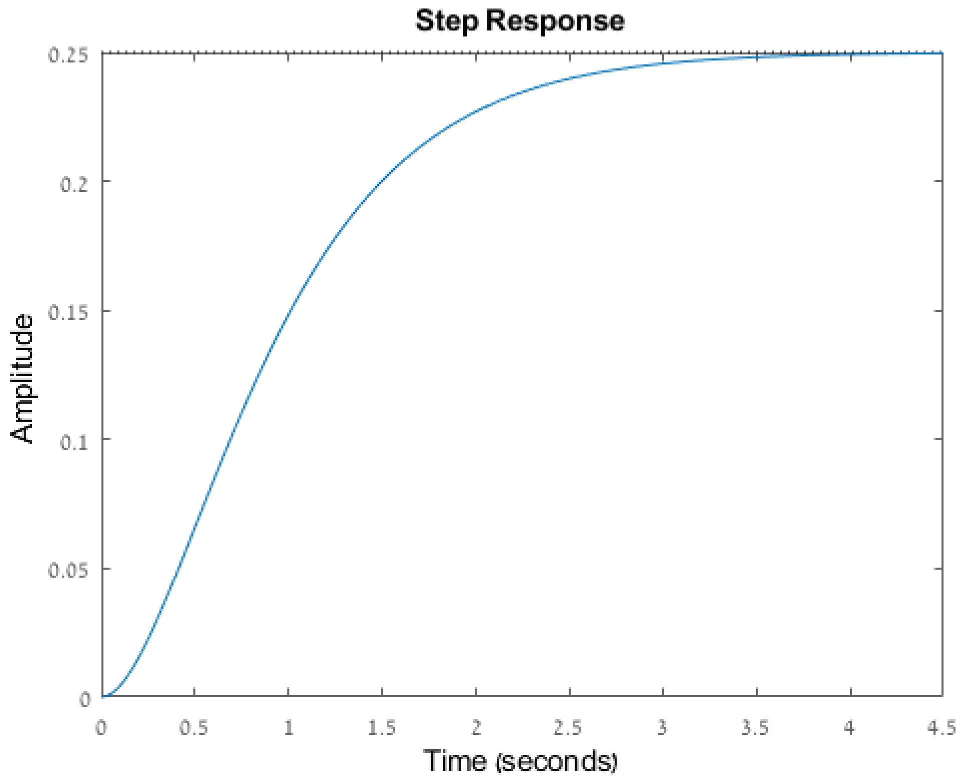
2.4

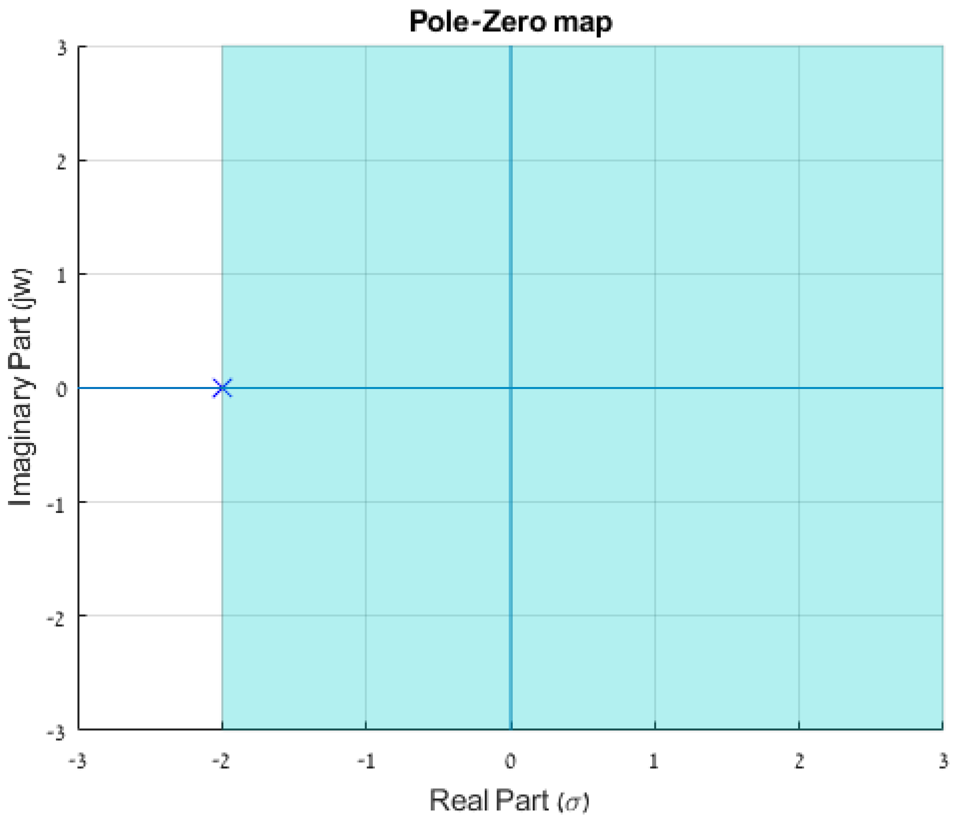
```
Y = [1 4 4];
X = [0 0 1];
tf(X,Y)
step(tf(X,Y));
pzplot2(X,Y);
```

```
ans =

        1
  -------------
  s^2 + 4 s + 4

Continuous-time transfer function.
```





5 First order system step response

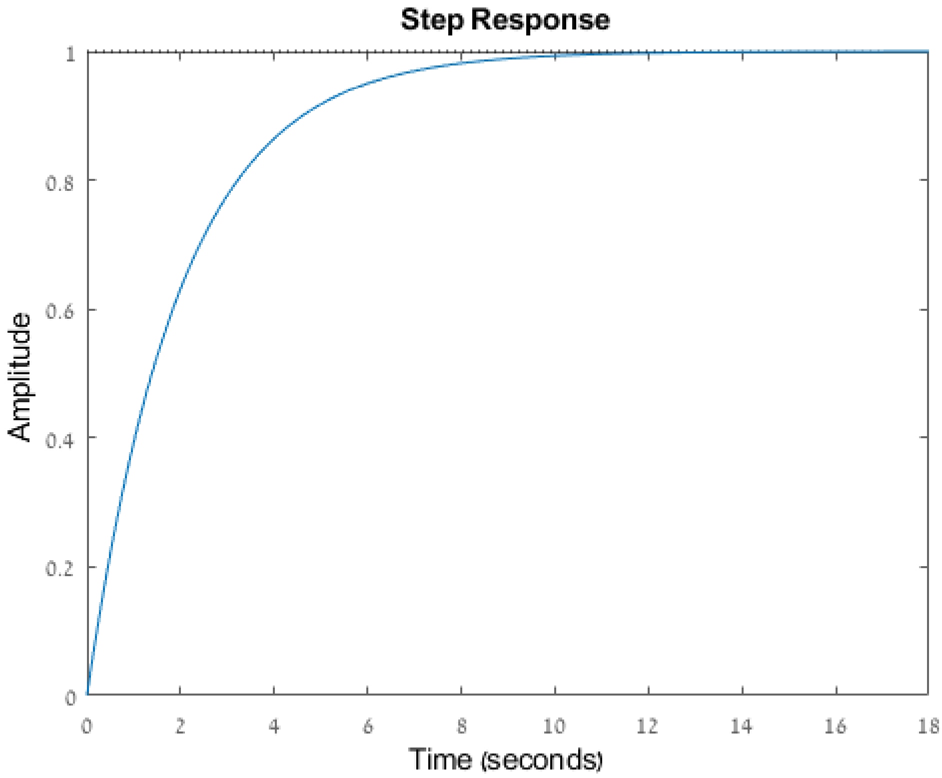
T = 2

```
Y = [0 2 1];
X = [0 0 1];
tf(X,Y)
step(tf(X,Y));
```

```
ans =

     1
  -------
  2 s + 1

Continuous-time transfer function.
```



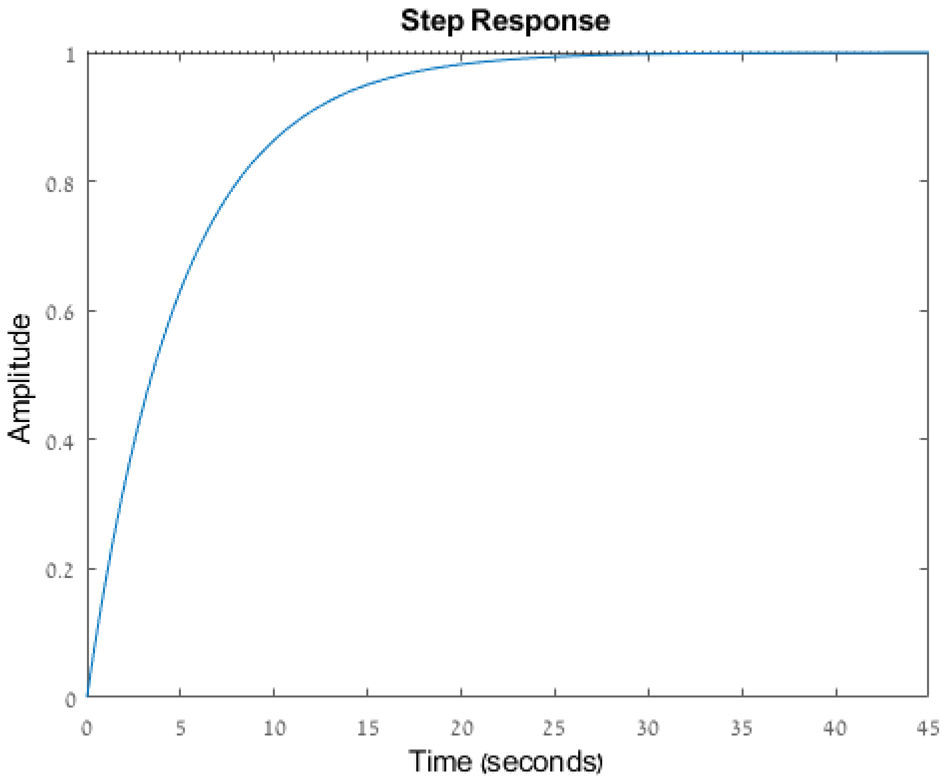
T = 5

```
Y = [0 5 1];
X = [0 0 1];
tf(X,Y)
step(tf(X,Y));
```

```
ans =

     1
  -------
  5 s + 1

Continuous-time transfer function.
```



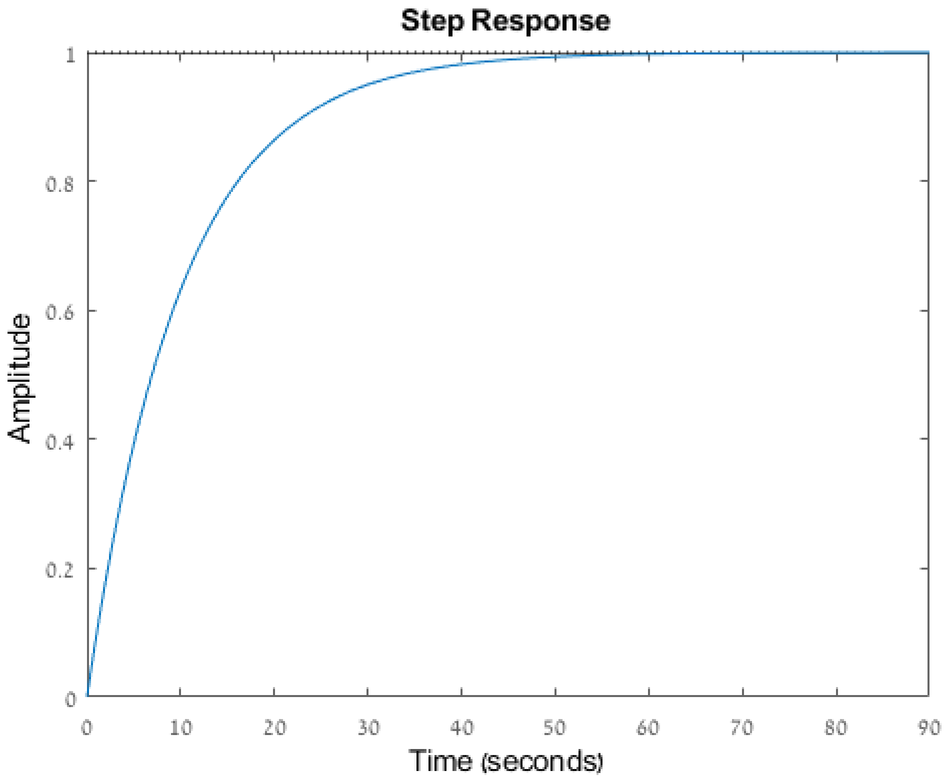
T = 10

```
Y = [0 10 1];
X = [0 0 1];
tf(X,Y)
step(tf(X,Y));
```

```
ans =

     1
  --------
  10 s + 1

Continuous-time transfer function.
```



The greater the coefficent of s, the slower the convergence of the function is.

6 A closed loop system

6.1

```
Y = [1 20 1000 5000];
X = [0 0 0 5000];
T = tf(X,Y);
T_Y = Y;
T_X = X;
tf(X,Y)
```

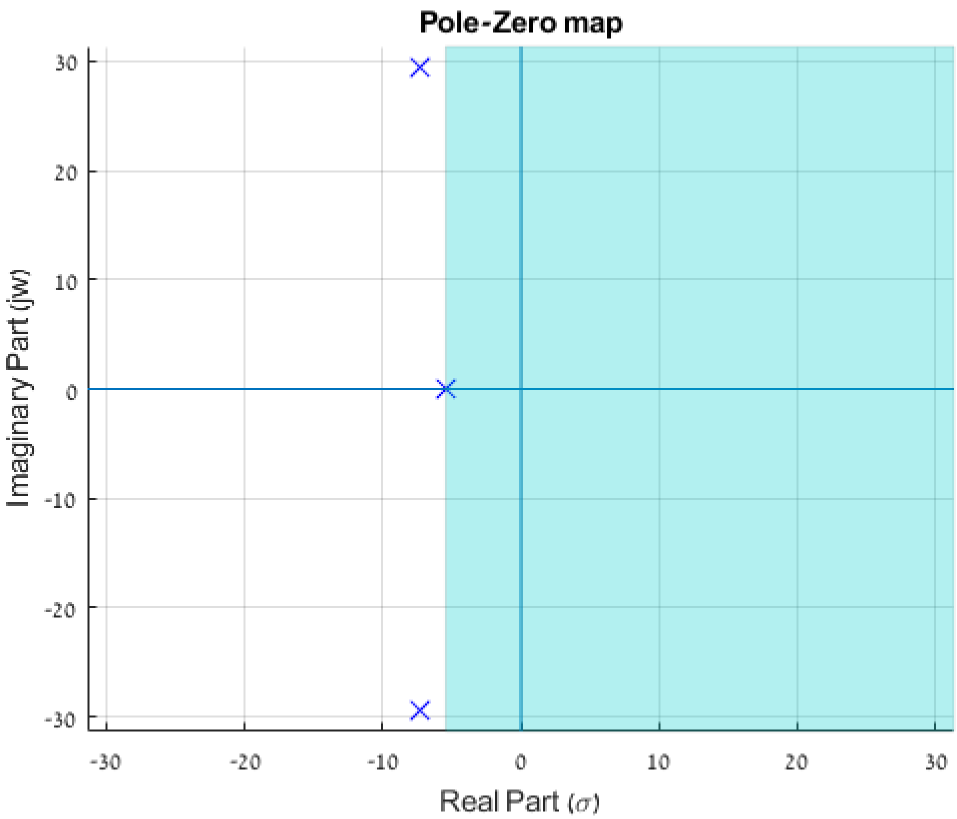
```
ans =

                5000
  ----------------------------
  s^3 + 20 s^2 + 1000 s + 5000

Continuous-time transfer function.
```

6.2

```
[zeros,poles] = pzplot2(X,Y);
zeros;
poles;
```



6.3

```
Y = [1 20 1000 5000 0];
X = [0 0 0 0 5000];
tf(X,Y)
[r,p,k] = residue(X,Y);
r;
p;
k;
```

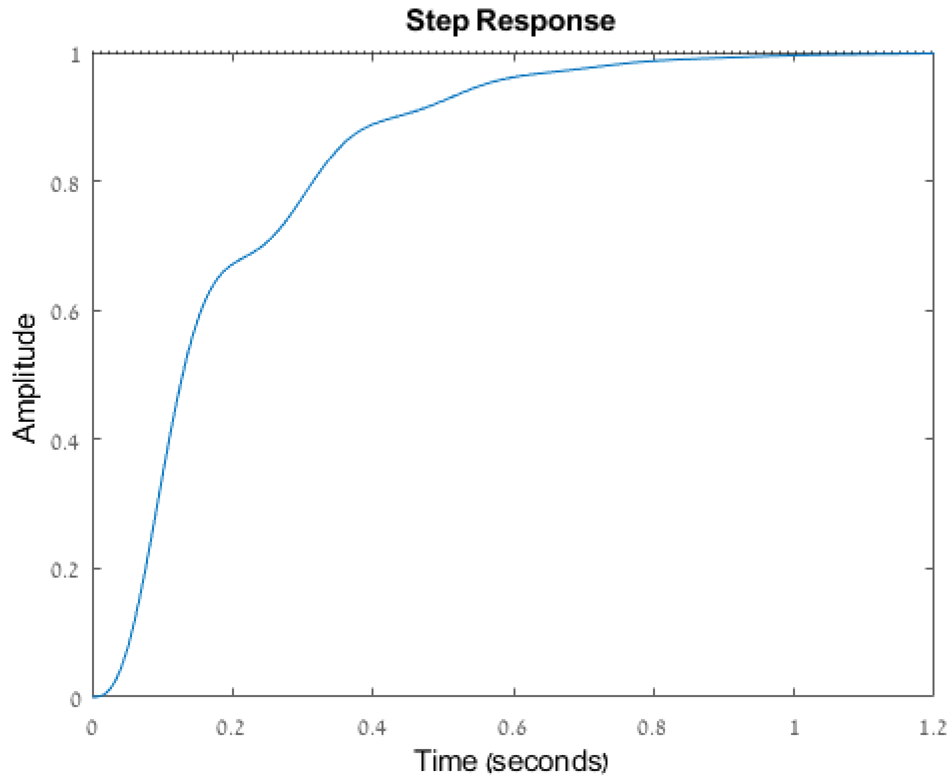
```
ans =

                5000
  --------------------------------
  s^4 + 20 s^3 + 1000 s^2 + 5000 s

Continuous-time transfer function.
```

6.4

```
step(T)
pzplot2(T_X,T_Y);
```




```
function [zeros,poles] = pzplot2(a,b)

    poles = complex(roots(b));
    max_pole = max(real(poles));
    zeros = complex(roots(a));
    axe = max([max(abs(zeros)) max(abs(poles))]);

    figure

    plot(zeros,'o','MarkerEdgeColor','red','MarkerSize',10)
    hold on
    plot(poles, 'x','MarkerEdgeColor','blue','MarkerSize',10)
    grid, axis([-axe-1 axe+1 -axe-1 axe+1])
    hold on
    xL = xlim;
    yL = ylim;
    line([0 0], yL);  %x-axis
    line(xL, [0 0]);  %y-axis
    hold on
    patch_x = [max_pole; max_pole; axe+1; axe+1];
    patch_y = [-axe-1; axe+1; axe+1; -axe-1];
    patch(patch_x,patch_y,[0,0.8,0.8],'edgeAlpha',0.1);
    alpha(0.3)
    hold off

    title('Pole-Zero map')
    xlabel('Real Part (\sigma)')
    ylabel('Imaginary Part (jw)')

end
```

```
ans =

   0.0000 + 1.0000i
```

```
0.0000 - 1.0000i
```

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