Islamic Azad University, Najafabad Branch
Department of Mechanical Engineering

Control Systems Engineering by Matlab

Dr. Soleimani

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Entering the polynomial $p(s) = s^3 + 3s^2 + 4$ and calculating its roots.

```
>>p=[1 3 0 4];
>>r=roots(p)

r =
 -3.3553
  0.1777+ 1.0773i
  0.1777- 1.0773i
>>p=poly(r)
p =


  1.0000    3.0000    0.0000    4.0000
```

$p(s) = s^3 + 3s^2 + 4$

Calculate roots of $p(s) = 0$.

Reassemble polynomial from roots.

Using **conv** and **polyval** to multiply and evaluate the polynomials $(3s^2 + 2s + 1)(s + 4)$.

```
>>p=[3 2 1]; q=[1 4];
>>n=conv(p,q)
n=
   3    14    9    4

>>value=polyval(n,-5)
value =

  -66
```

Multiply p and q.

$n(s) = 3s^3 + 14s^2 + 9s + 4$

Evaluate $n(s)$ at $s = -5$.

The **tf** function

$$G(s) = \frac{\text{num}}{\text{den}}$$

```
>> num1=[10];den1=[1 2 5];
>> sys1=tf(num1,den1)

Transfer function:
       10
------------------
s^2 + 2 s + 5
```

← $G_1(s)$

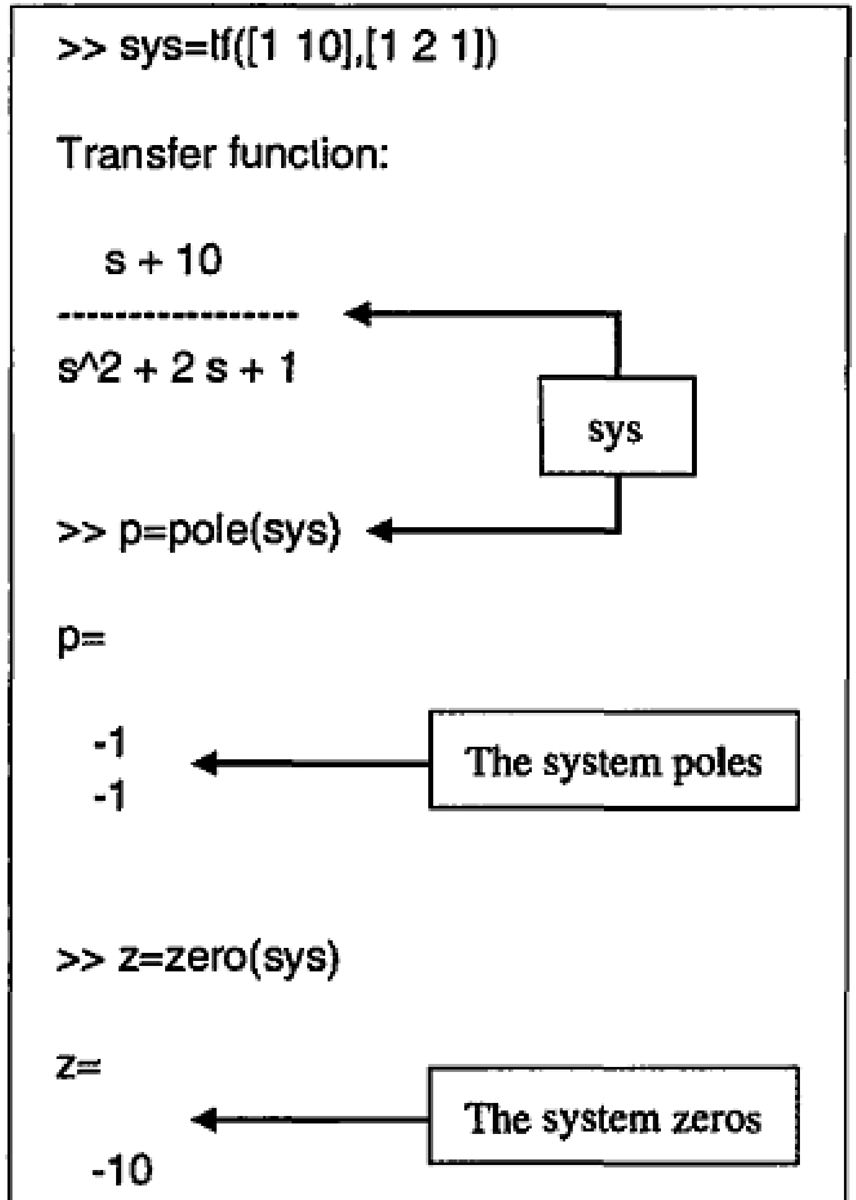
```
>> num2=[1];den2=[1 1];
>> sys2=tf(num2,den2)

Transfer function:
   1
-------
s + 1
```

← $G_2(s)$

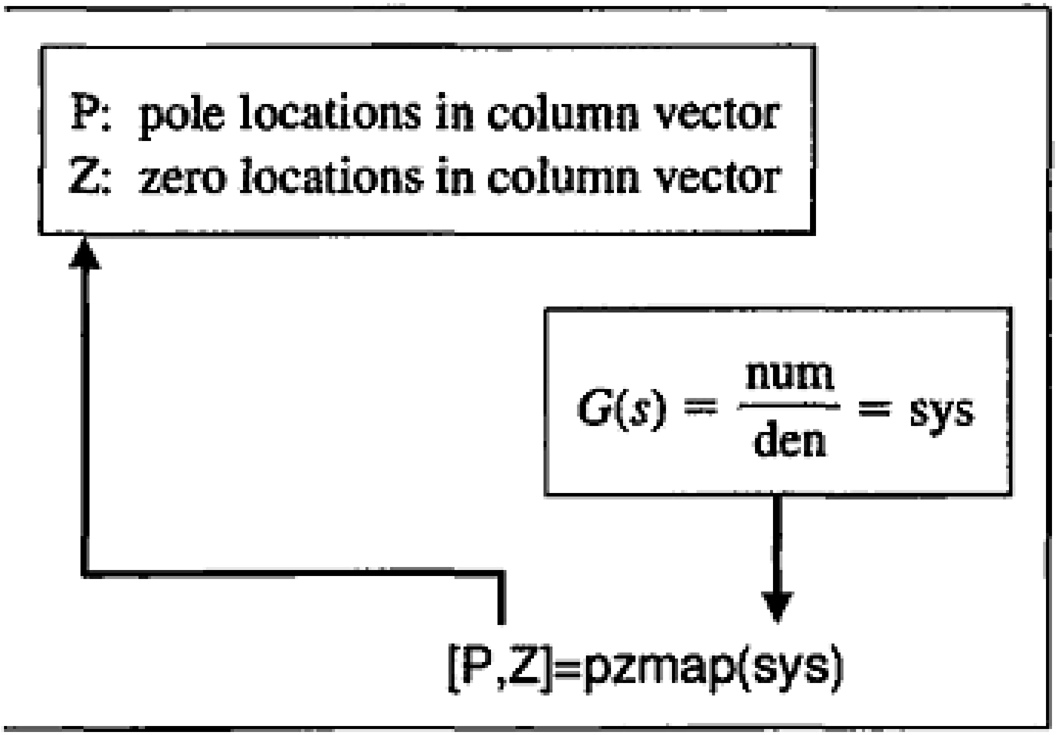
```
>> sys=sys1+sys2

Transfer function:
    s^2 + 12 s + 15
-------------------------------
s^3 + 3 s^2 + 7 s + 5
```

← $G_1(s) + G_2(s)$

The **pole** and **zero** functions



The **pzmap** function.



Pole–zero map for $G(s)/H(s)$.

```
>>numg=[6 0 1]; deng=[1 3 3 1];sysg=tf(numg,deng);
>>z=zero(sysg)

z =
    0 + 0.4082i
    0 - 0.4082i

>>p=pole(sysg)

p =
   -1.0000
   -1.0000 + 0.0000i
   -1.0000 -  0.0000i

>>n1=[1 1]; n2=[1 2]; d1=[1 2*i]; d2=[1 -2*i]; d3=[1 3];
>>numh=conv(n1,n2); denh=conv(d1,conv(d2,d3));
>>sysh=tf(numh,denh)

Transfer function:
      s^2 + 3 s + 2
----------------------
s^3 + 3 s^2 + 4 s + 12

>>sys=sysg/sysh

Transfer function:
6 s^5 + 18 s^4 + 25 s^3 + 75 s^2 + 4 s +12
-------------------------------------------
  s^5 + 6 s^4 + 14 s^3 + 16 s^2 + 9 s + 2

>>pzmap(sys)
```

Compute poles and zeros of $G(s)$

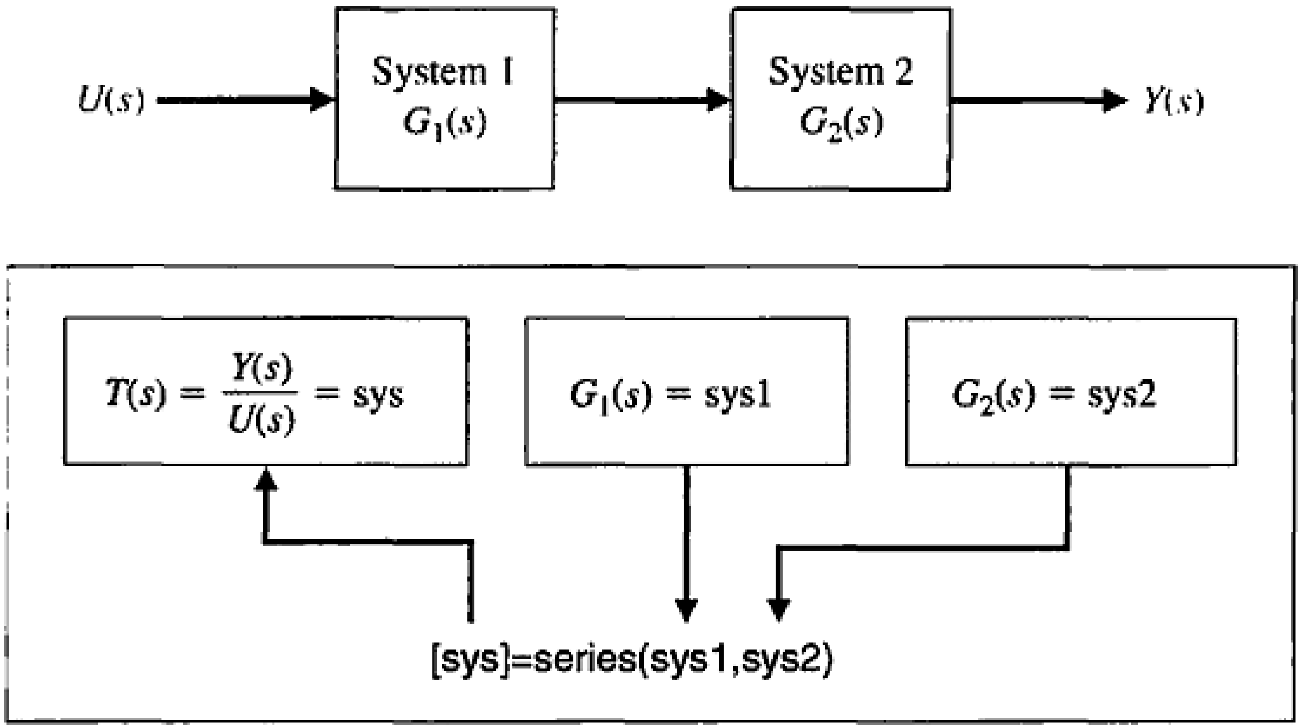
Expand $H(s)$

$H(s)$

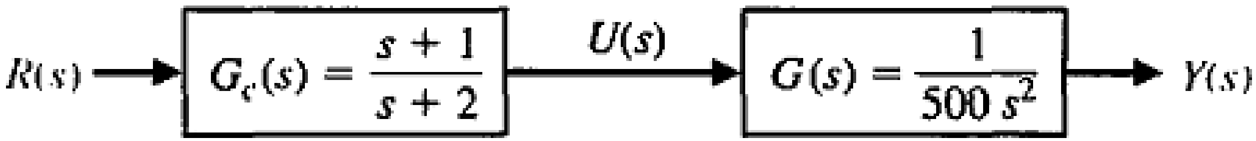
$\frac{G(s)}{H(s)} = \text{sys}$

Pole-zero map

The series function



The series function



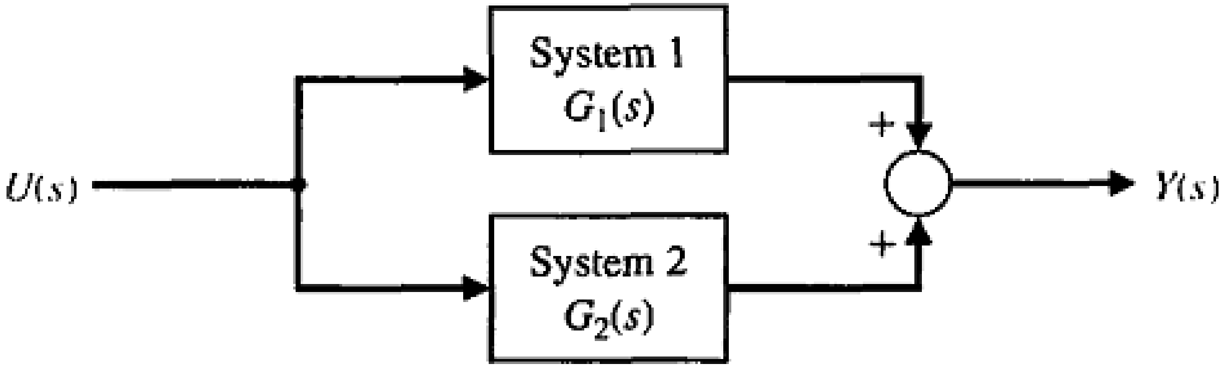
(a)

```
>>numg=[1]; deng=[500 0 0]; sysg=tf(numg,deng);
>>numh=[1 1]; denh=[1 2]; sysh=tf(numh,denh);
>>sys=series(sysg,sysh);
>>sys

Transfer function:
         s + 1
--------------------
500 s^3 + 1000 s^2
```

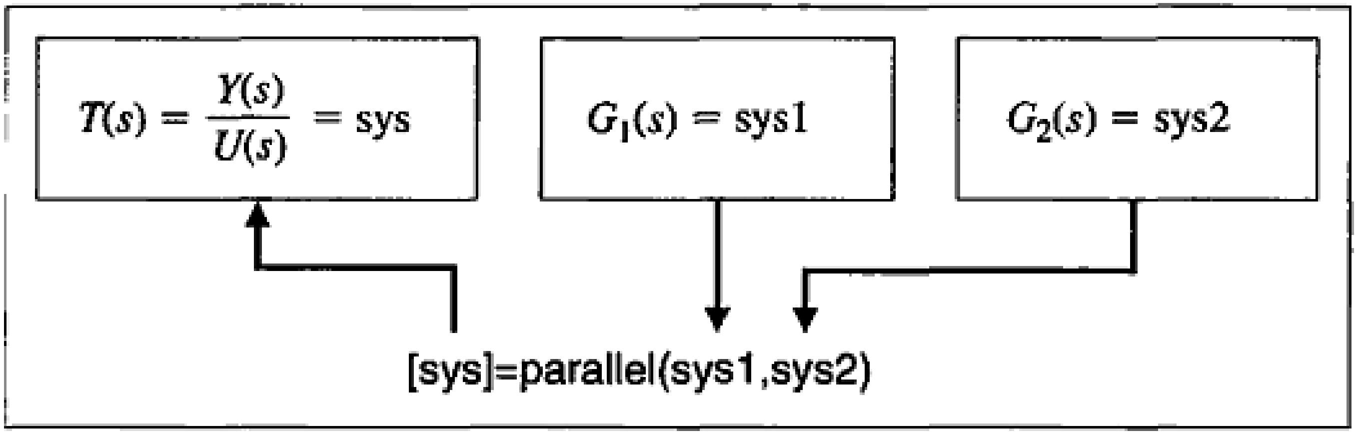
← $G_c(s)G(s)$

(b)

The parallel function

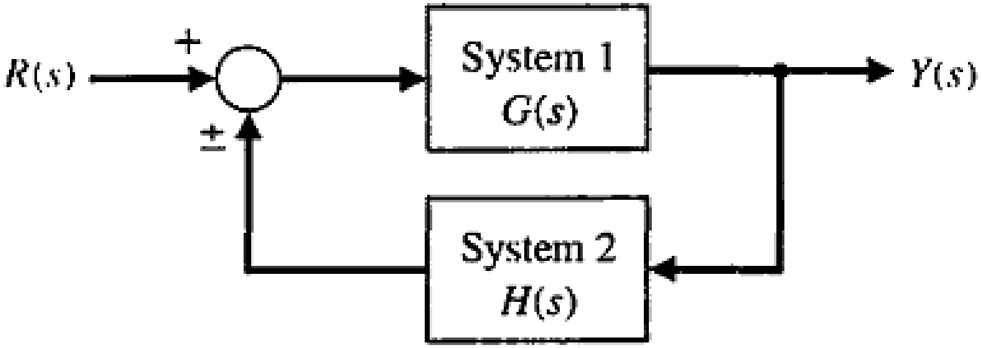


(a)

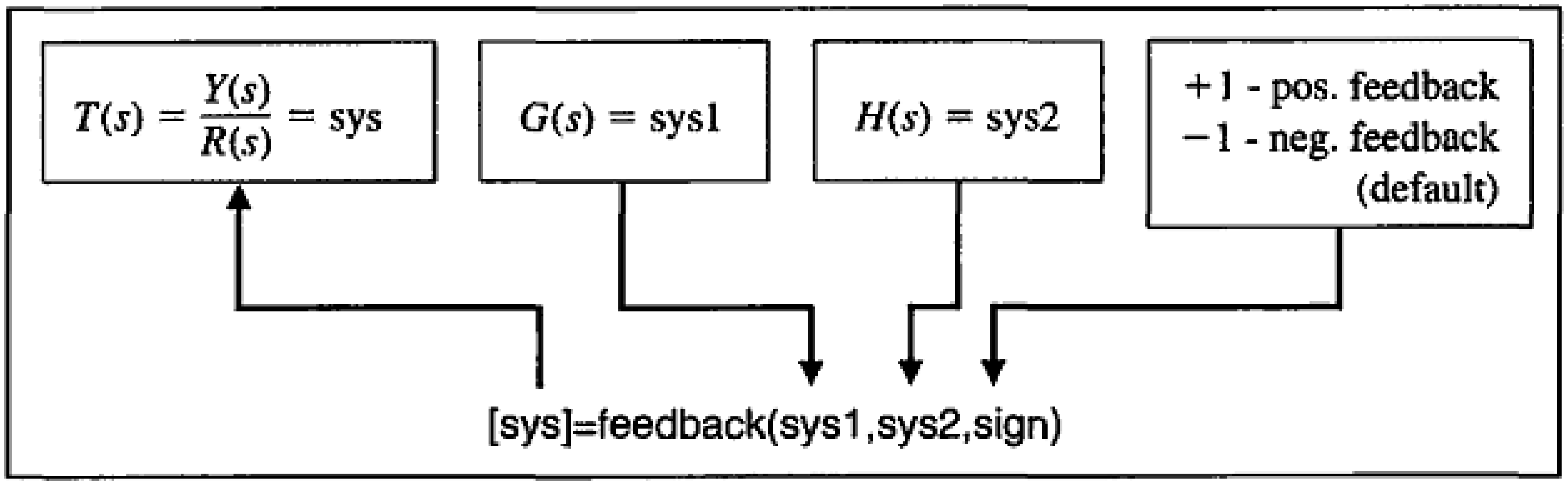


(b)

The feedback function

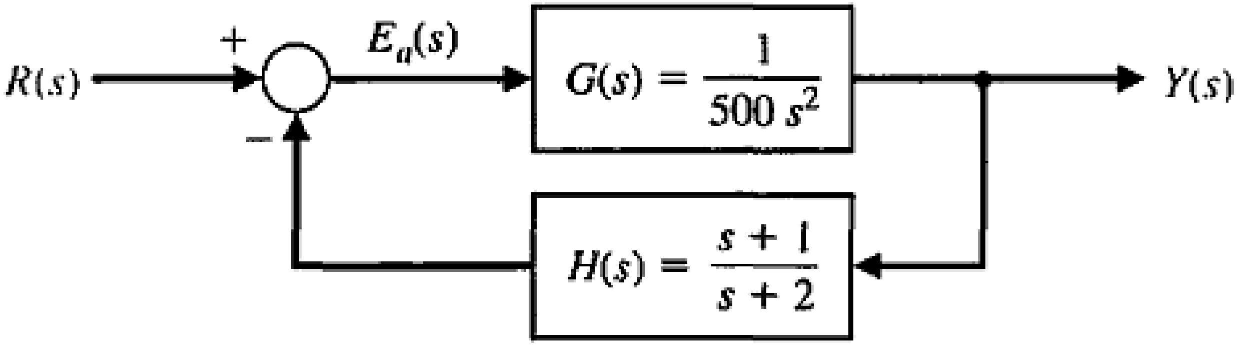


(a)



(b)

The feedback function



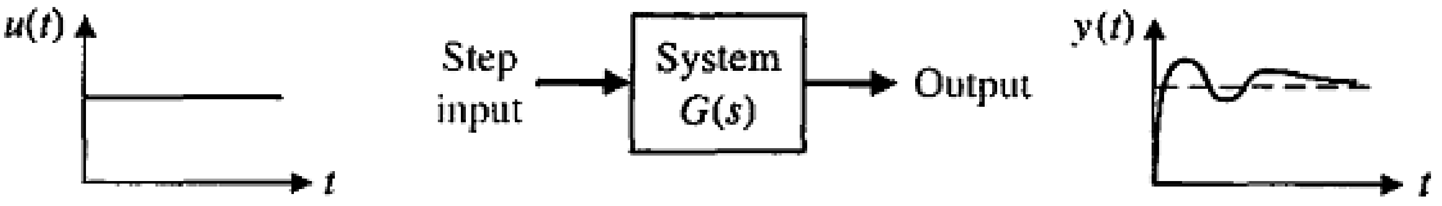
(a)

```
>>numg=[1]; deng=[500 0 0]; sys1=tf(numg,deng);
>>numh=[1 1]; denh=[1 2]; sys2=tf(numh,denh);
>>sys=feedback(sys1,sys2);
>>sys

Transfer function:

          s + 2
---------------------------
500 s^3 + 1000 s^2 + s + 1
```

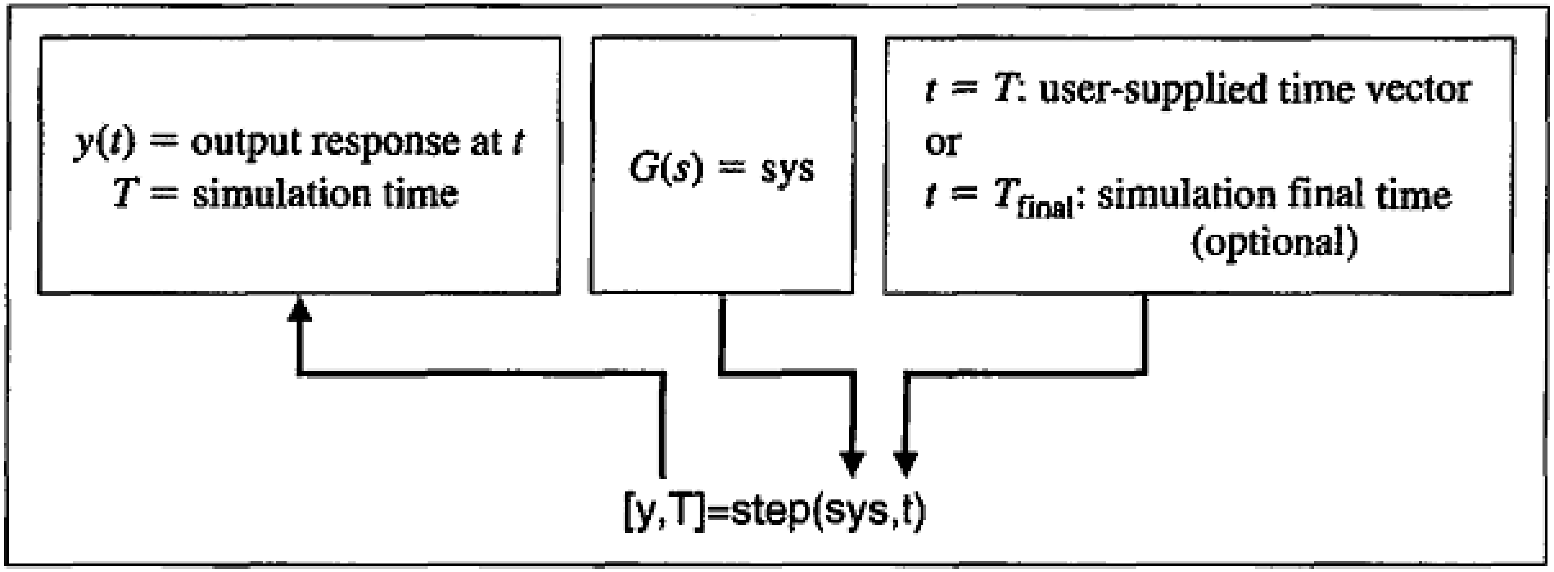
$$\frac{Y(s)}{R(s)} = \frac{G(s)}{1 + G(s)H(s)}$$

(b)

The step function



(a)



(b)

The step function

```
% This script computes the step
% response of the traction motor
% wheel velocity
%
num=[5400]; den=[2 2.5 5402]; sys=tf(num,den);
t=[0:0.005:3];
[y,t]=step(sys,t);
plot(t,y),grid
xlabel('Time (s)')
ylabel('Wheel velocity')
```