PMR 3302
Sistemas Dinâmicos I

AULA 06: LAPLACE

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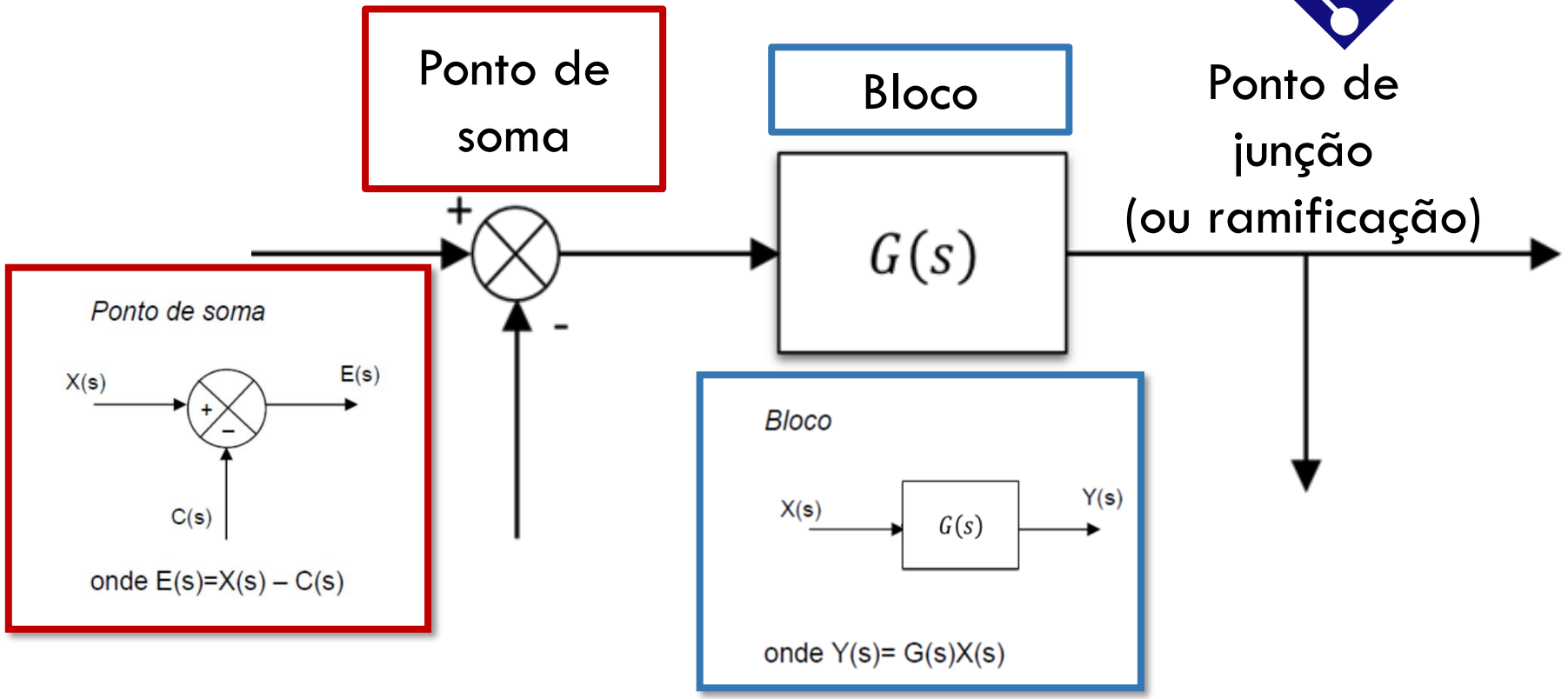
NOSSA AGENDA

#	Data	Tópico
1	21/02	Introdução ao modelamento e uso do software
2	06/03	Introdução à programação em MatLab
3	20/03	Resolução de Equações Diferenciais - Sistemas Lineares e Não Lineares
4	03/04	Transformada de Laplace e Funções de Transferência
5	24/04	Projeto
6	15/05	Diagrama de Blocos
7	29/05	Análise de Sistemas de Primeira Ordem
8	19/06	Análise de Sistemas de Segunda Ordem

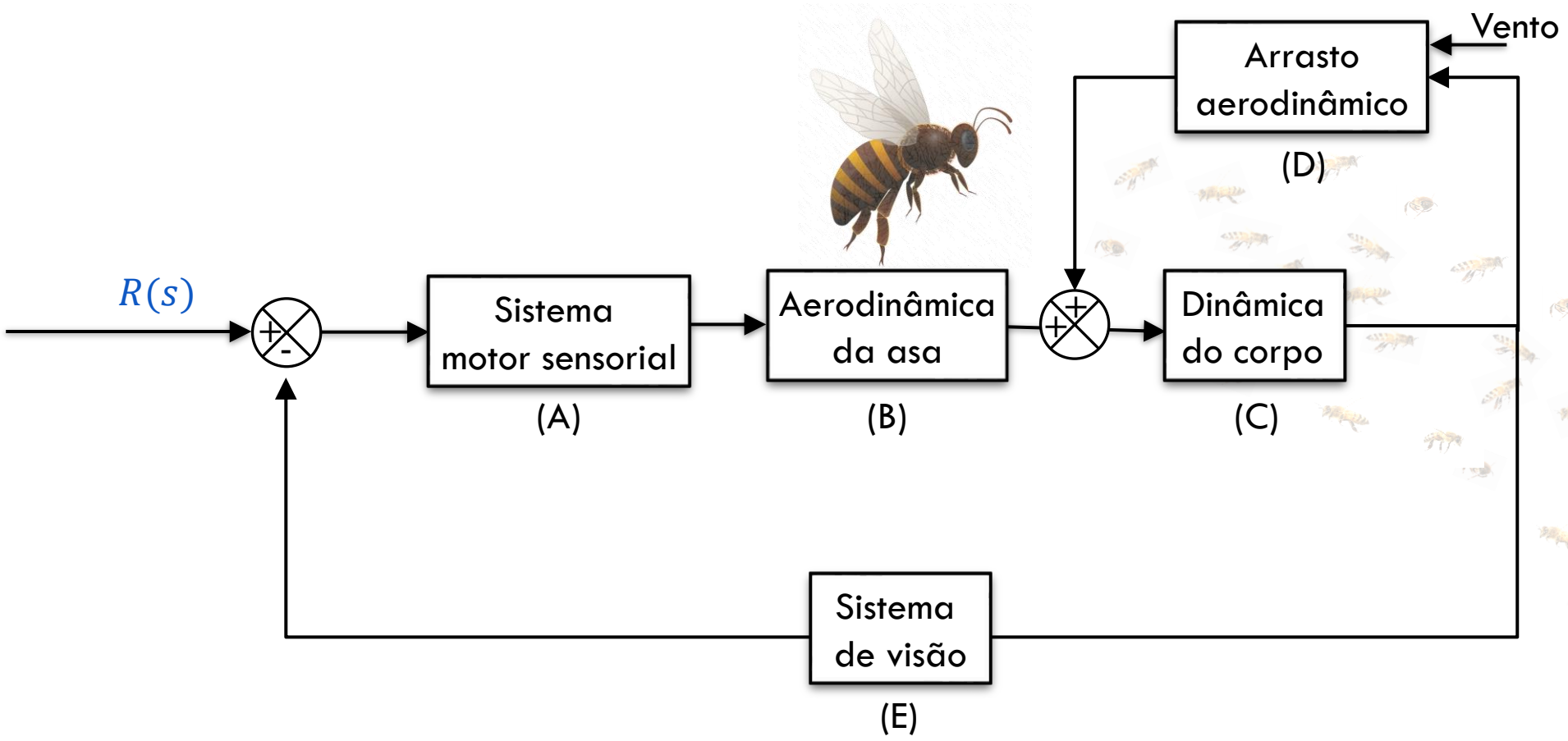
PARTE I: DIAGRAMA DE BLOCOS

- É uma representação gráfica das funções desempenhadas por cada componente e o fluxo de sinais entre eles. Descreve o interrelacionamento que existe entre os vários componentes.

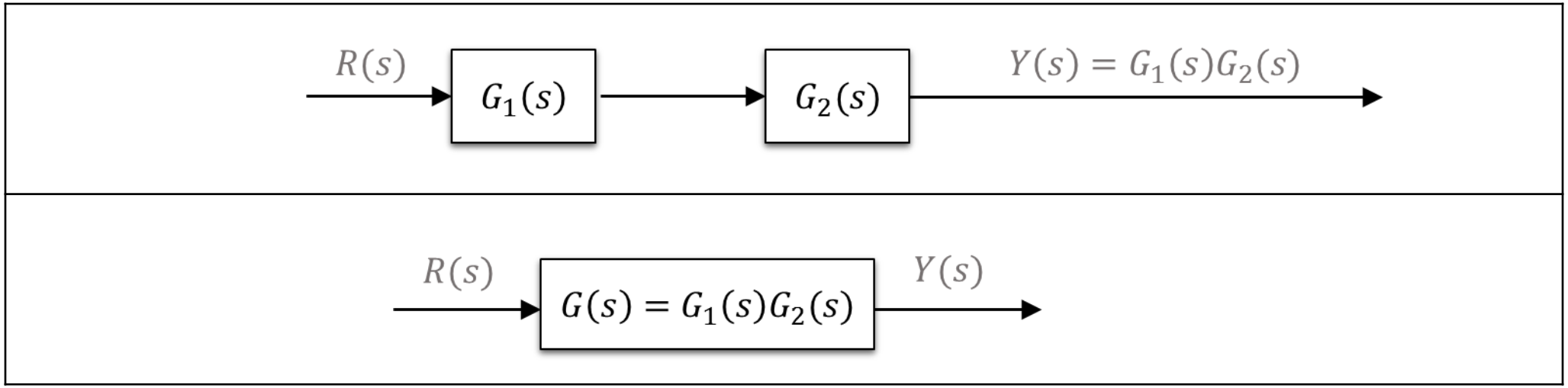


Um diagrama de blocos contem informações relativas ao **comportamento dinâmico,** mas não inclui nenhuma informação sobre a construção física do sistema.

DIAGRAMA DE BLOCOS

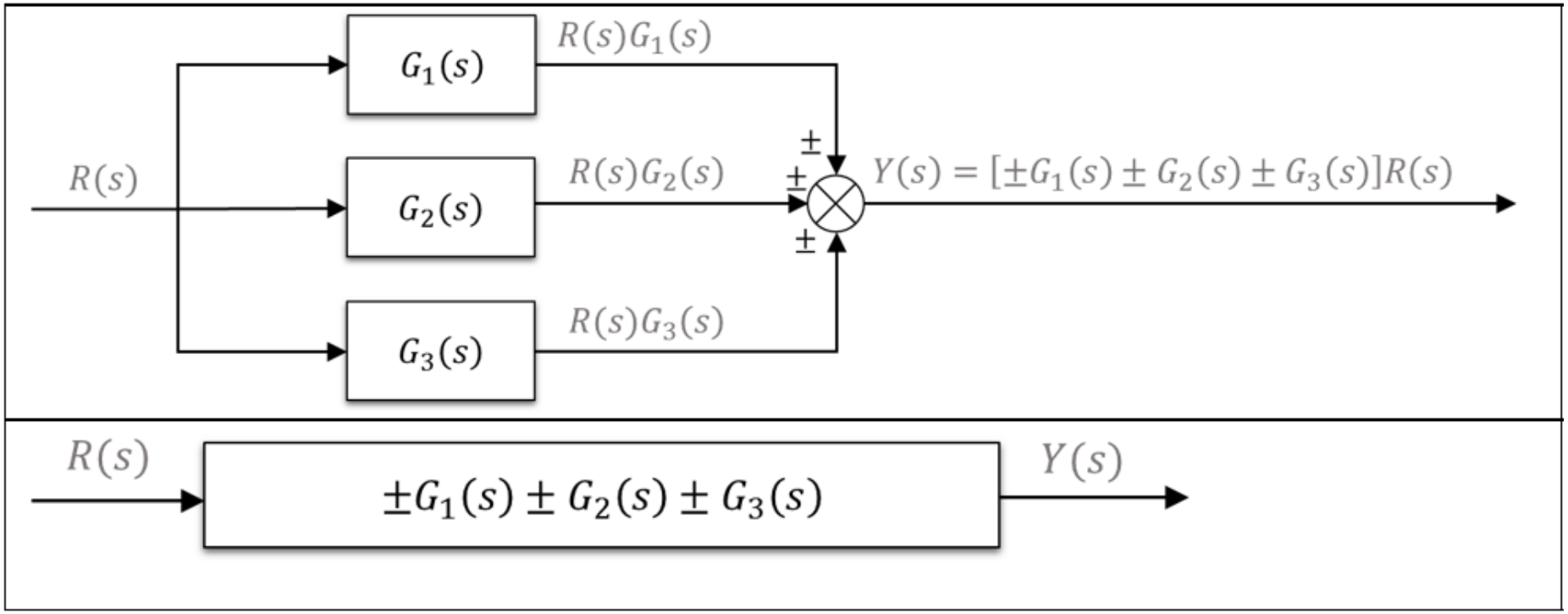


BLOCOS EM SÉRIE...



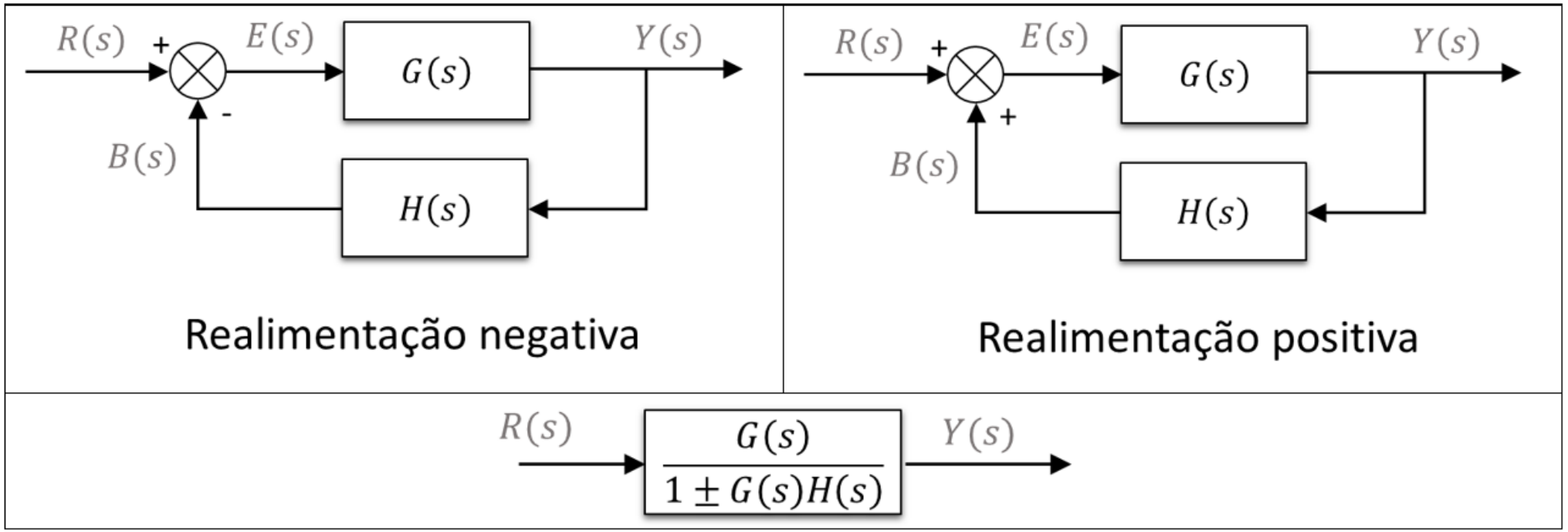
A função de transferência de uma série é o produto da função de transferência dos elementos da série

BLOCOS EM PARALELO...



A função de transferência de blocos em paralelo é a soma da função de transferência desses blocos

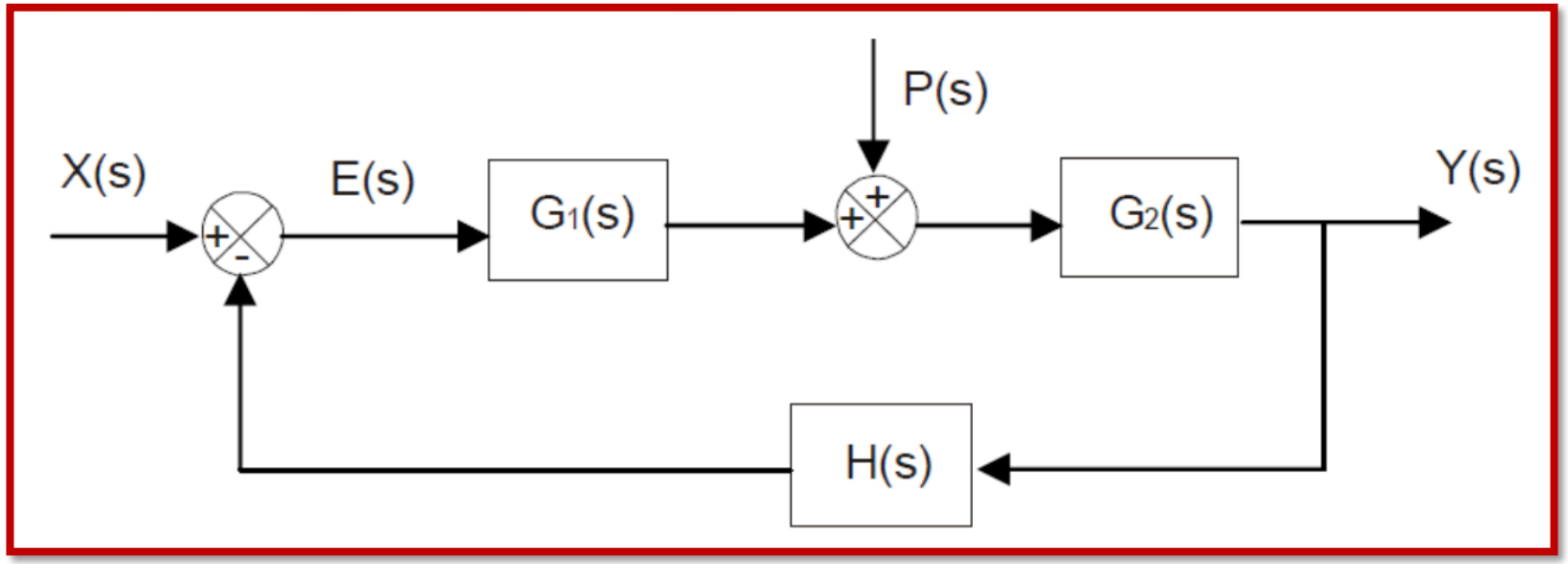
SISTEMA REALIMENTADO



FEEDBACK

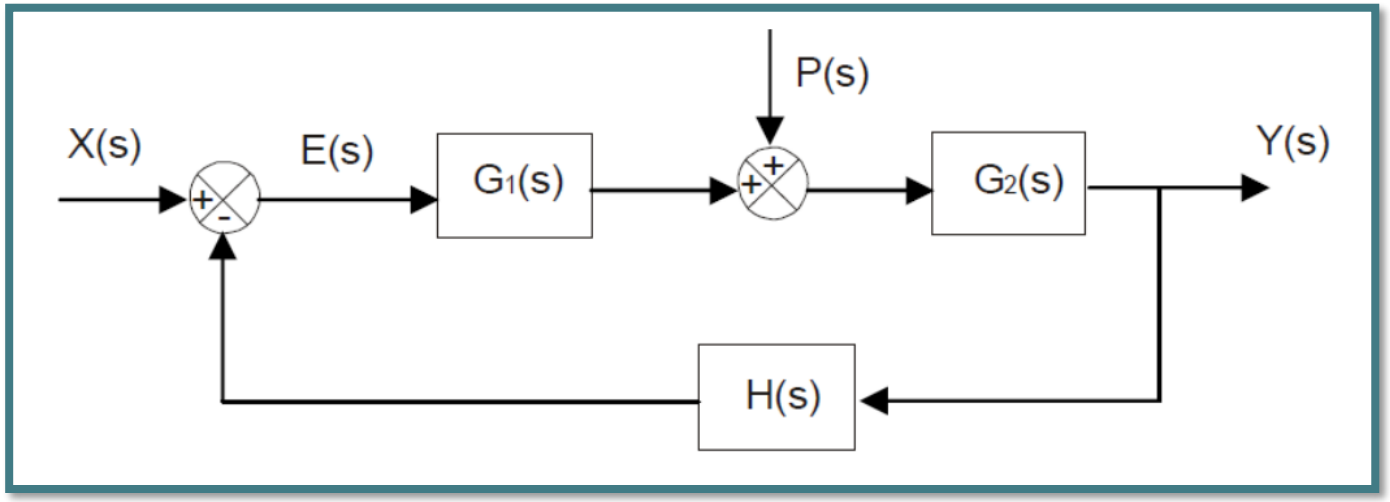
- https://www.mathworks.com/videos/understanding-control-systems-part-2-feedback-control-systems-123501.html

SISTEMA REALIMENTADO COM PERTURBAÇÃO

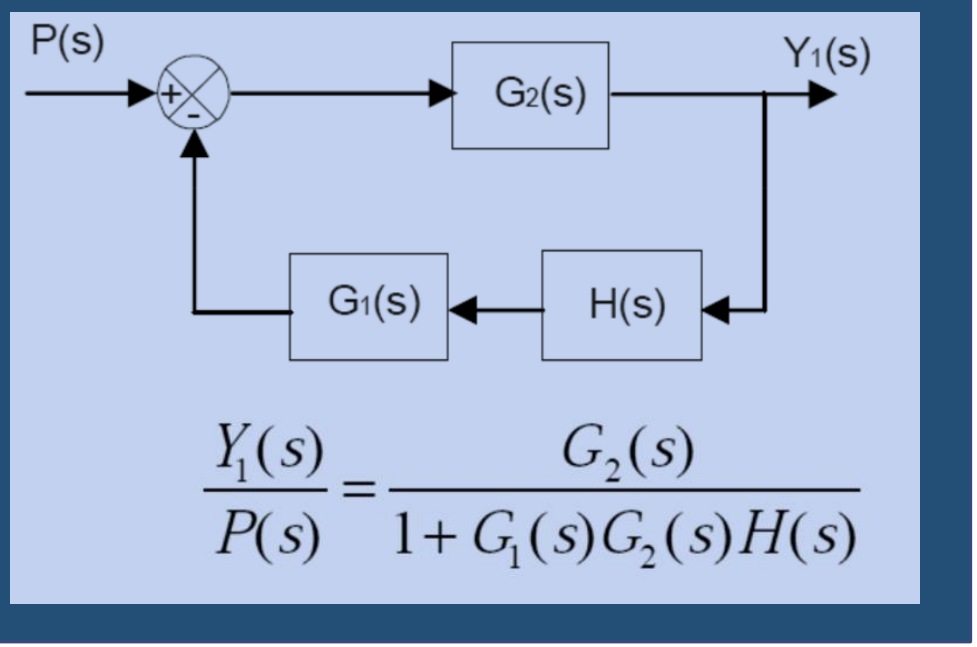


Considerando que o sistema com duas entradas $X(s)$ e $P(s)$ é linear, aplica-se o princípio da superposição:

"A saída de um sinal formado pela combinação linear de diferentes sinais, é igual à combinação dos sinais de saída gerados por cada sinal separadamente"

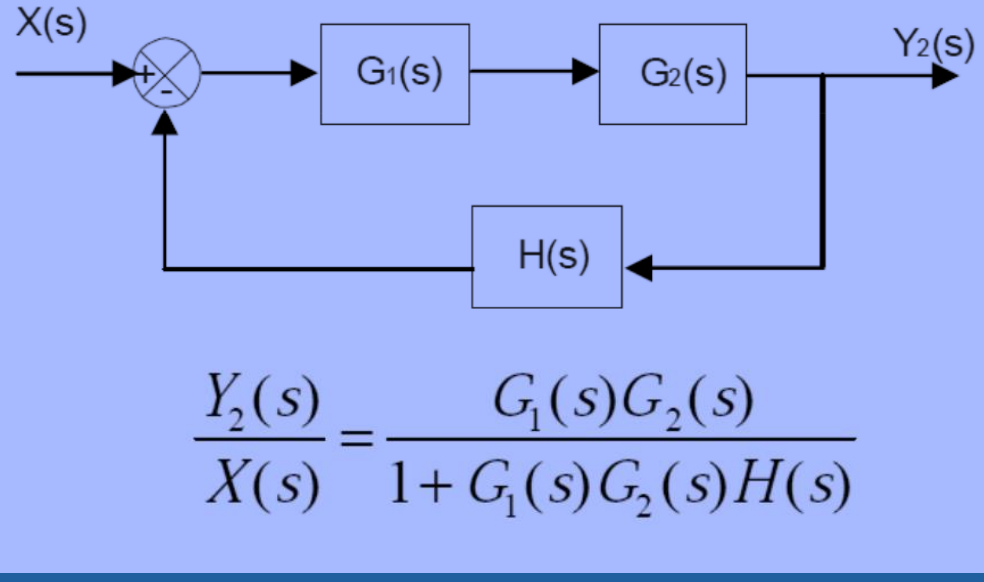


Efeito da perturbação:
$P(s) \rightarrow X(s) = 0$



$$\frac{Y_1(s)}{P(s)} = \frac{G_2(s)}{1 + G_1(s)G_2(s)H(s)}$$

Efeito da entrada:
$X(s) \rightarrow P(s) = 0$



$$\frac{Y_2(s)}{X(s)} = \frac{G_1(s)G_2(s)}{1 + G_1(s)G_2(s)H(s)}$$

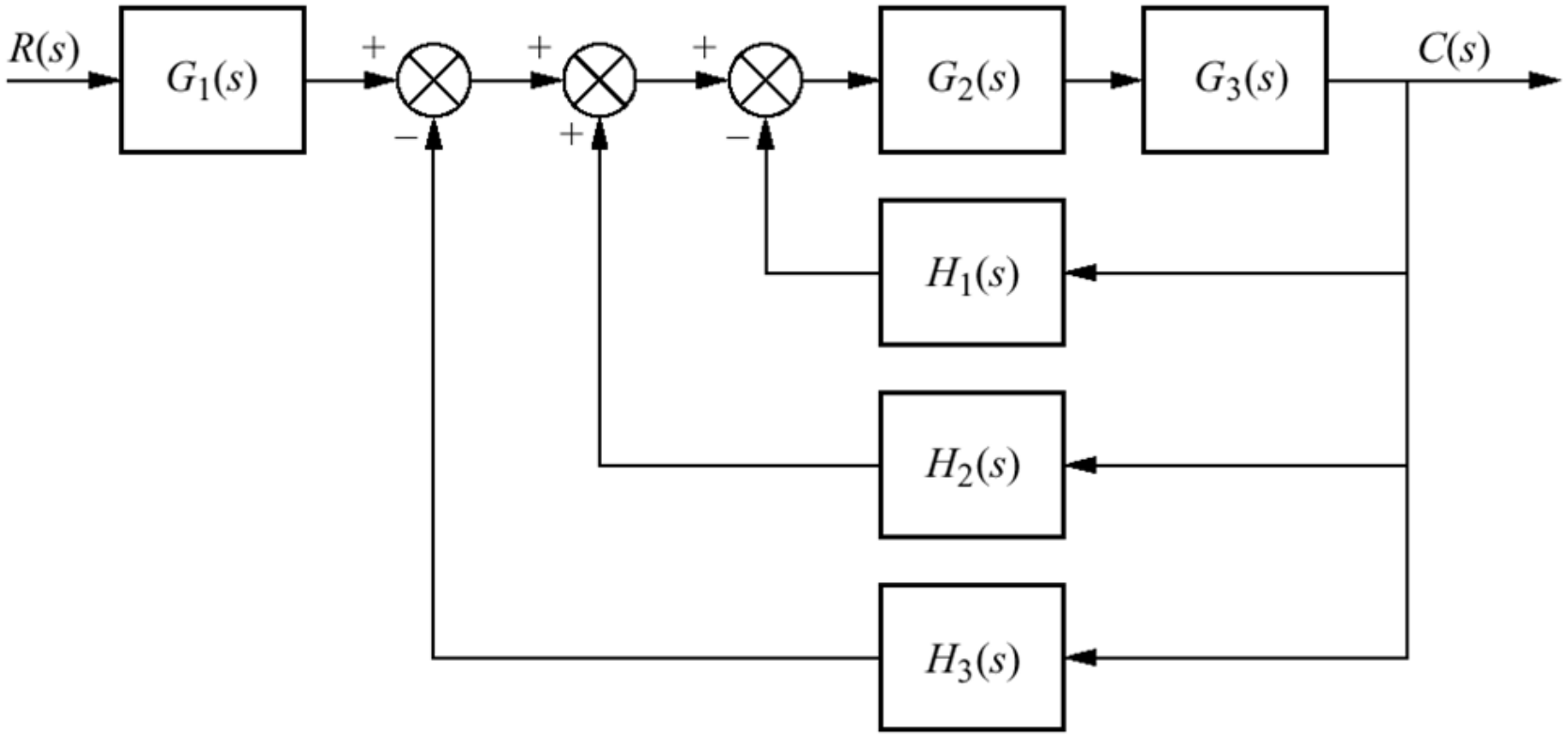
Resposta devido à aplicação simultânea das duas entradas

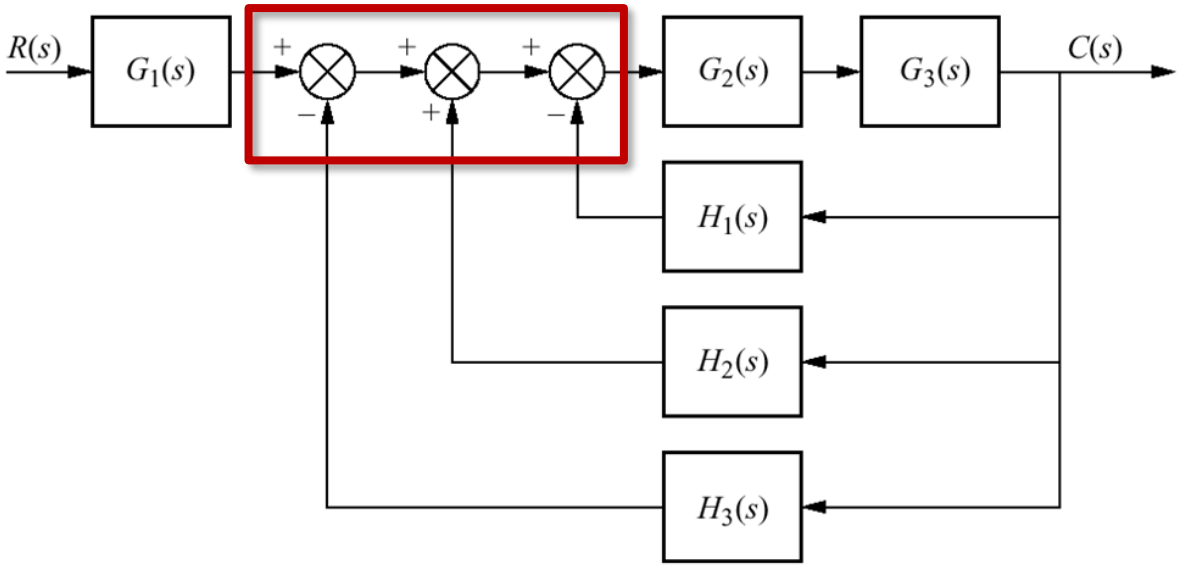
$$Y(s) = Y_1(s) + Y_2(s) = \frac{G_2(s)}{1 + G_1(s)G_2(s)H(s)} P(s) + \frac{G_1(s)G_2(s)}{1 + G_1(s)G_2(s)H(s)} X(s)$$

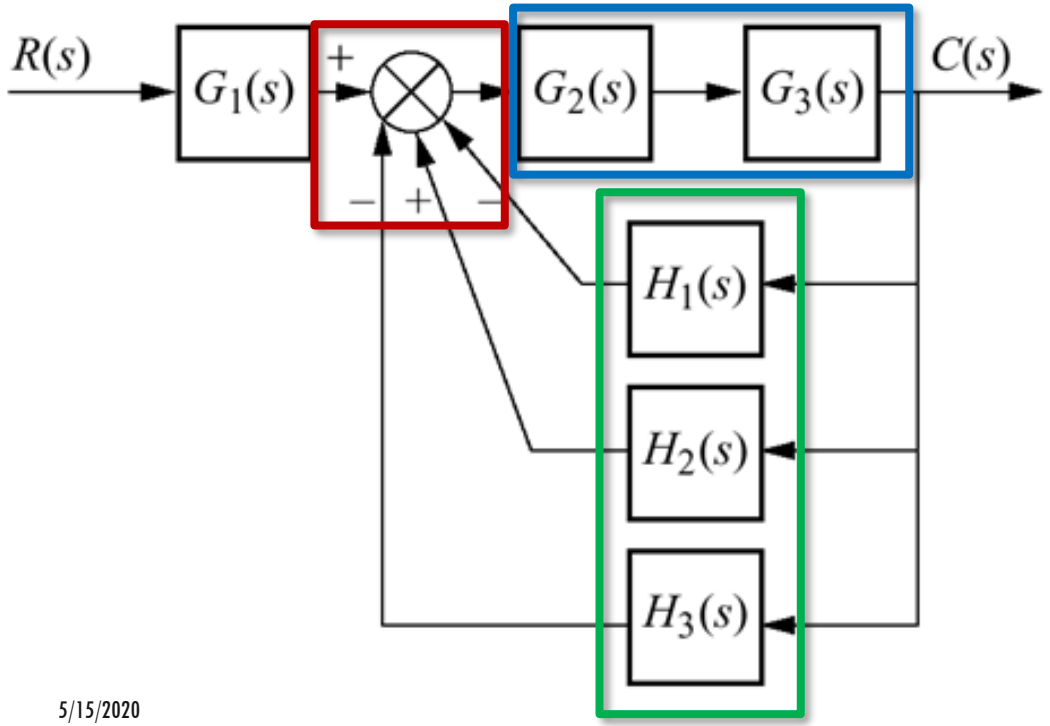
$$Y(s) = \frac{G_2(s)}{1 + G_1(s)G_2(s)H(s)} \left[G_1(s)X(s) + P(s) \right]$$

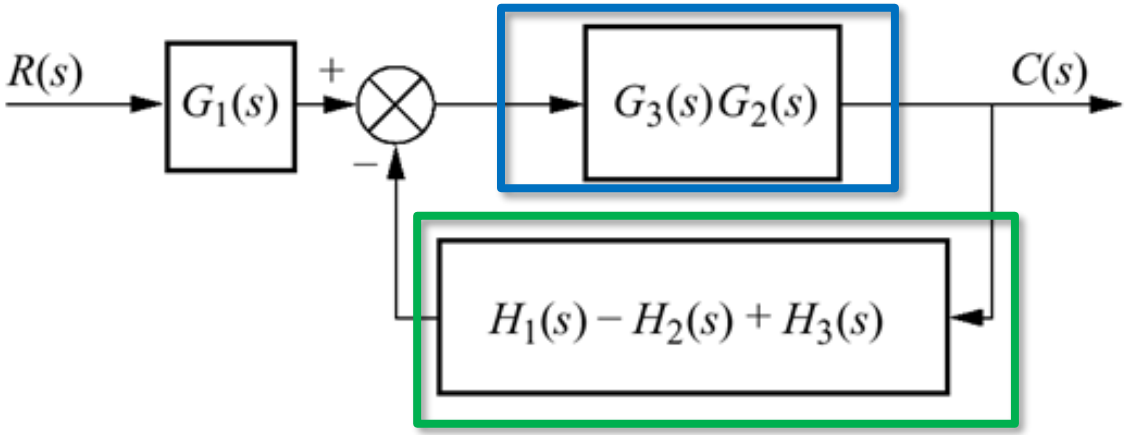
SIMPLIFICAÇÃO DE DIAGRAMA DE BLOCOS

1. Reduzir o seguinte diagrama de blocos para um único bloco





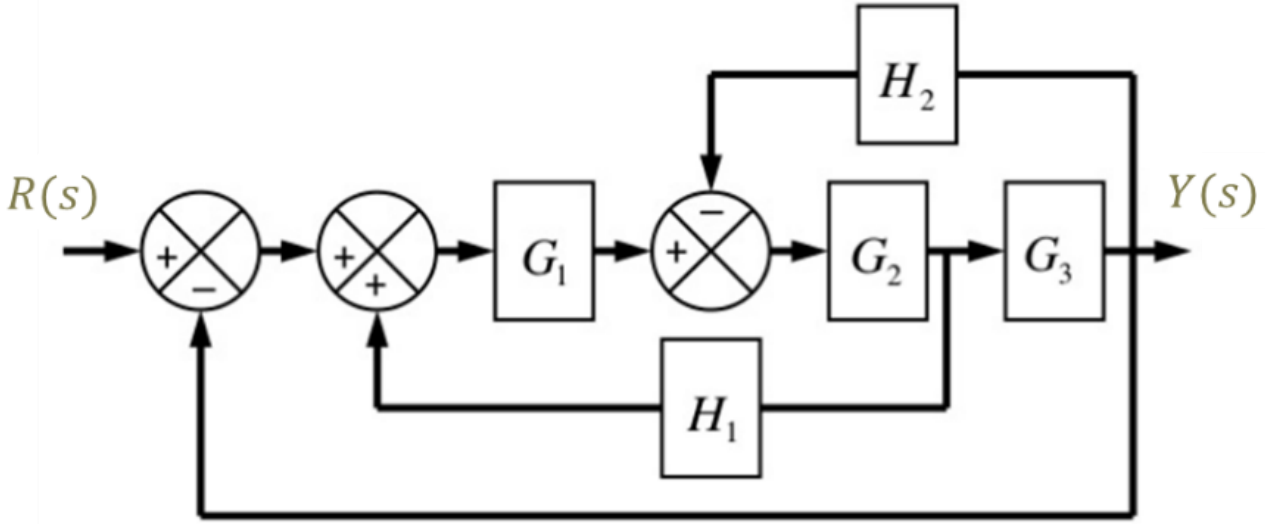




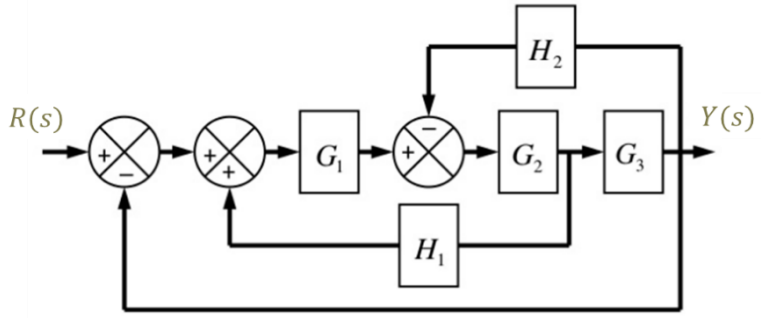
$$R(s) \rightarrow \frac{G_3(s)G_2(s)G_1(s)}{1 + G_3(s)G_2(s)[H_1(s) - H_2(s) + H_3(s)]} \rightarrow C(s)$$

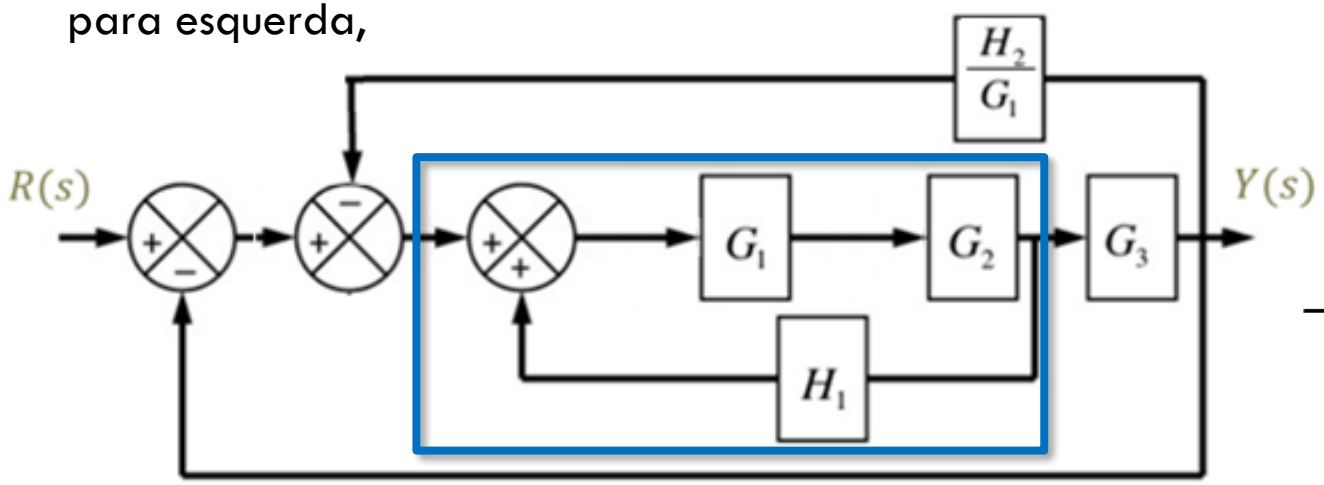
CONT...

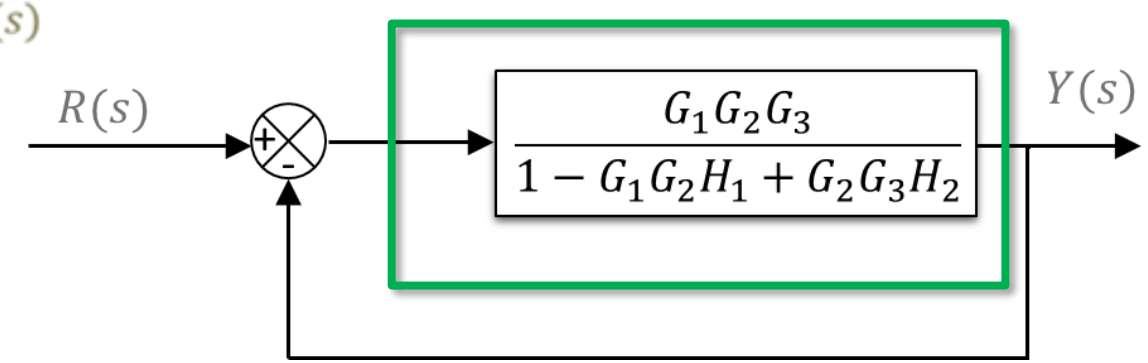
2. Reduzir o seguinte diagrama de blocos para um único bloco

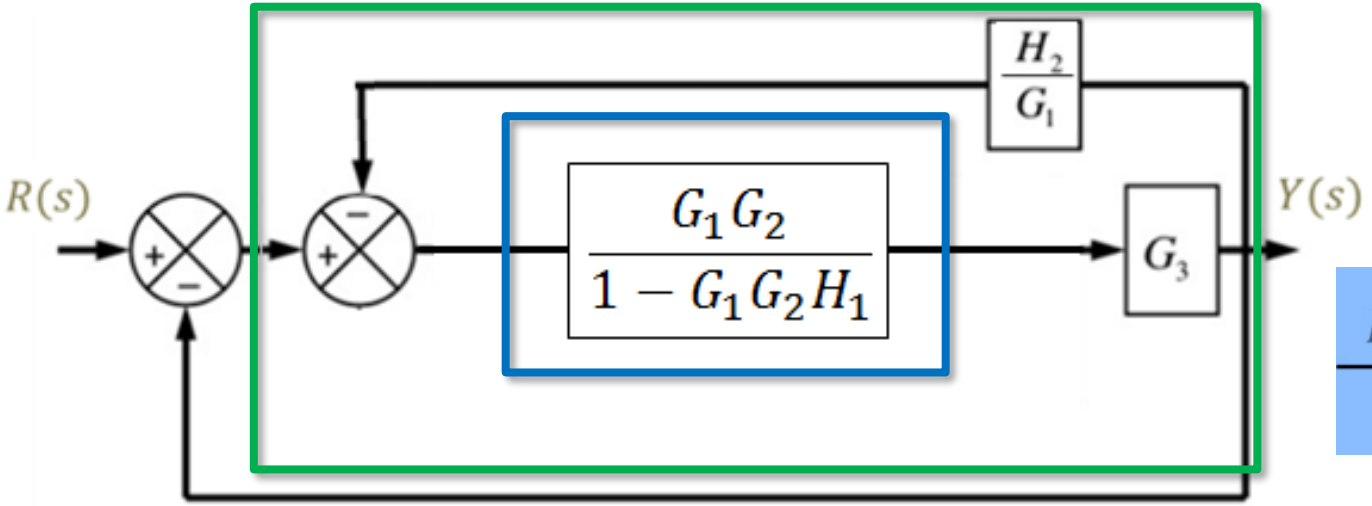


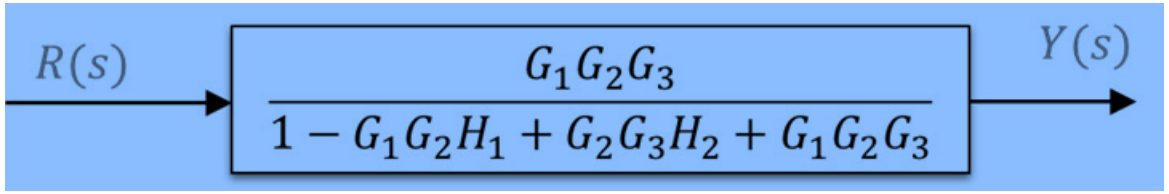
Move-se o ponto de soma do laço com H_2 para esquerda,





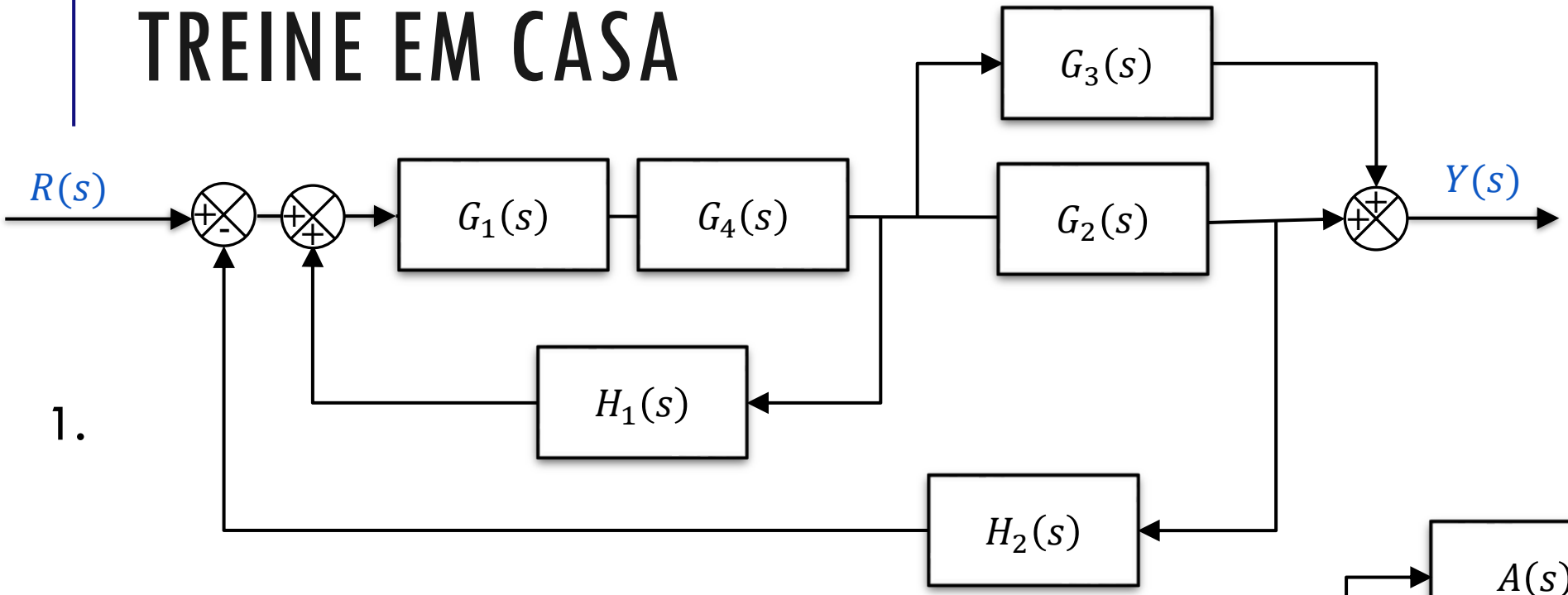




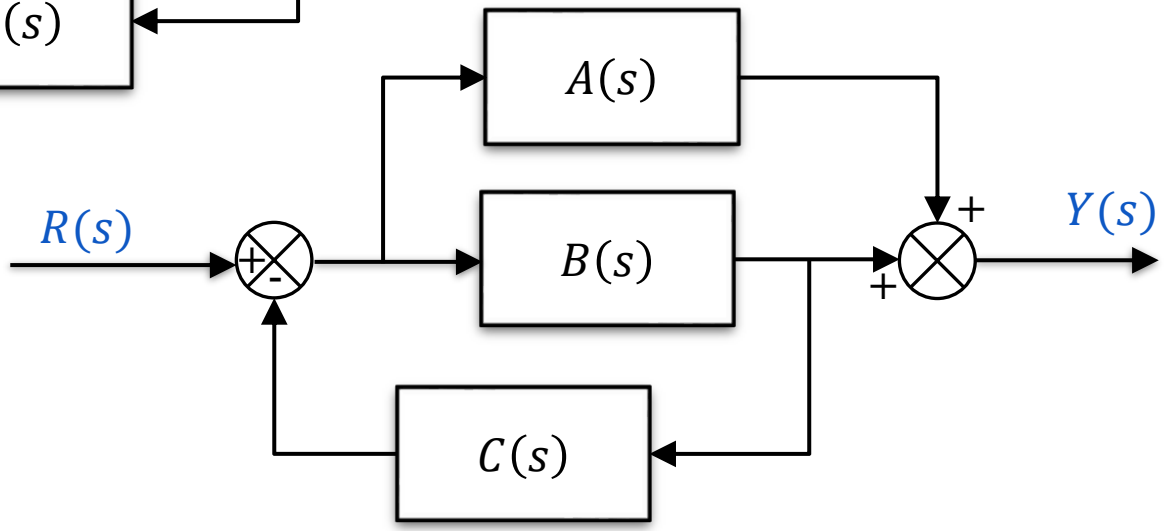


TREINE EM CASA

1.

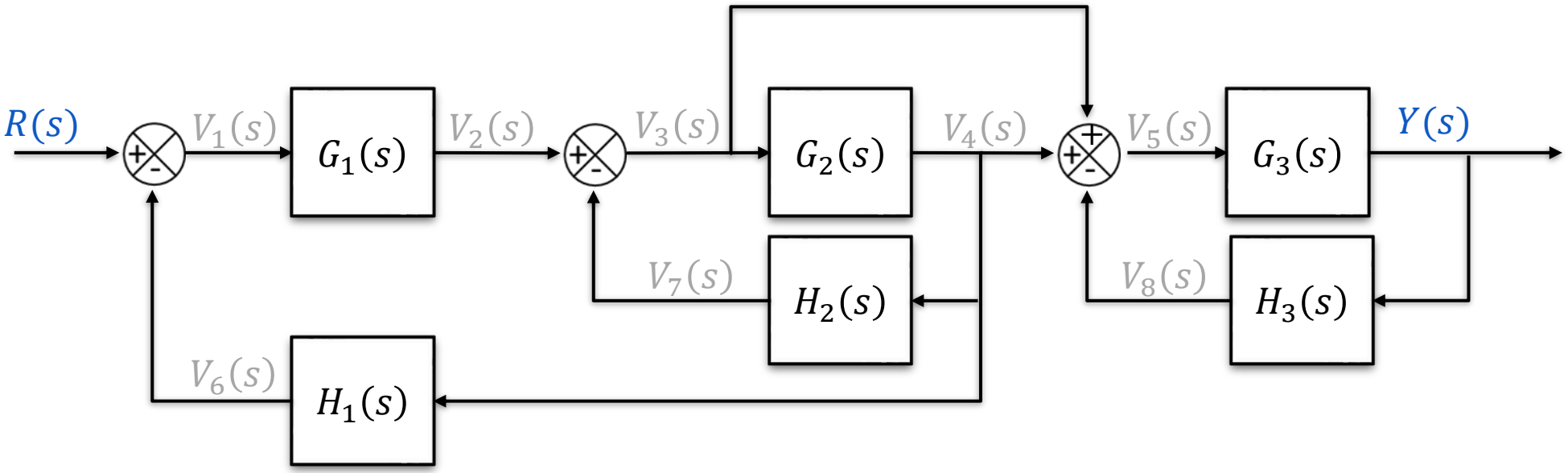


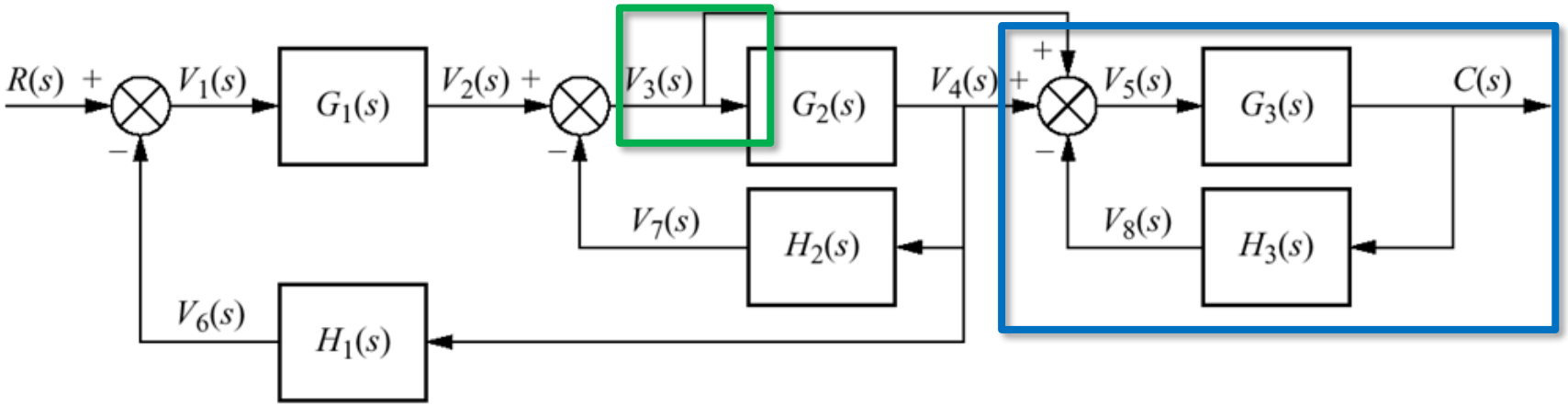
2.

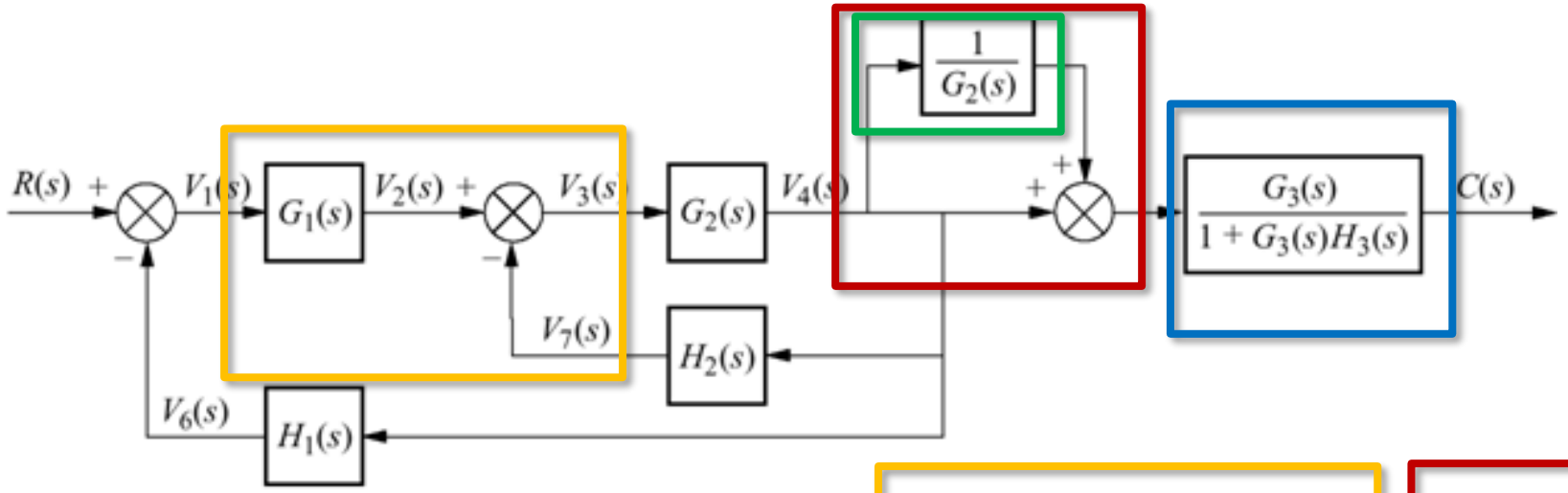


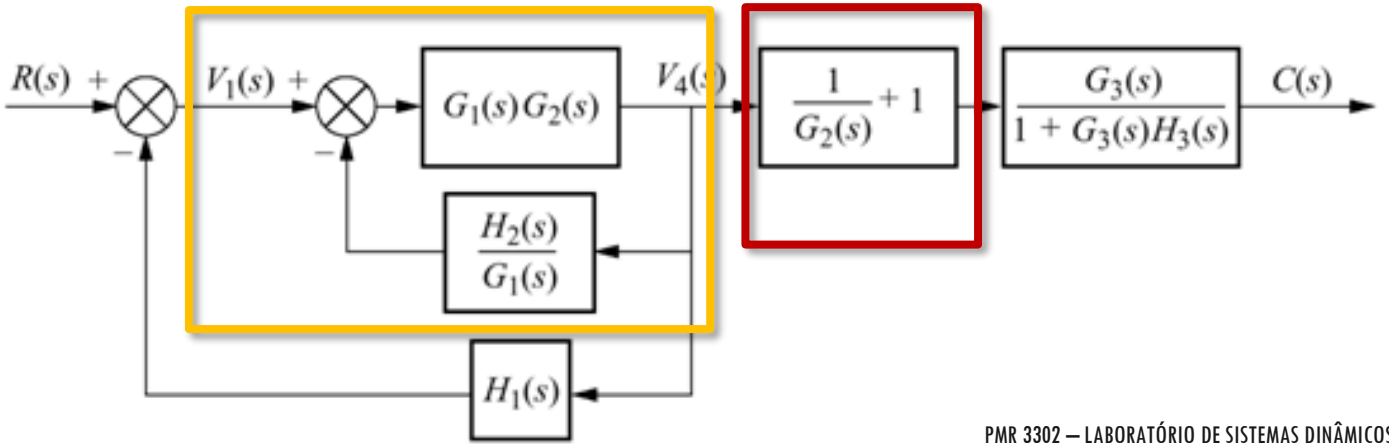
CONT...

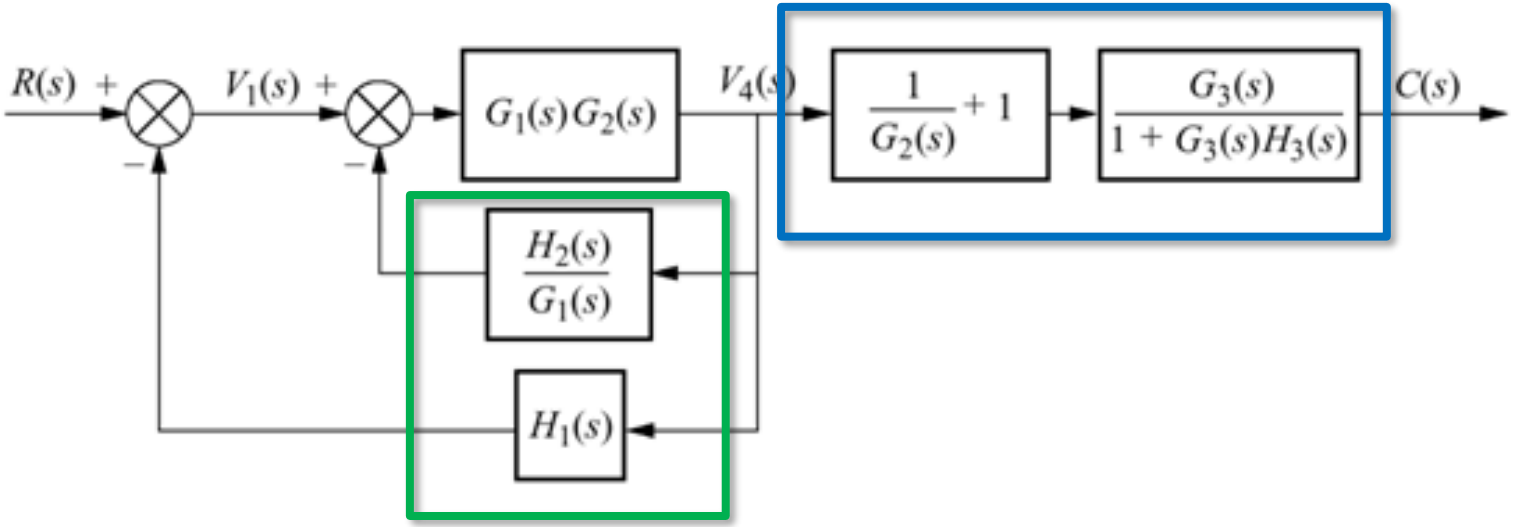
3. Reduzir o seguinte diagrama de blocos para um único bloco

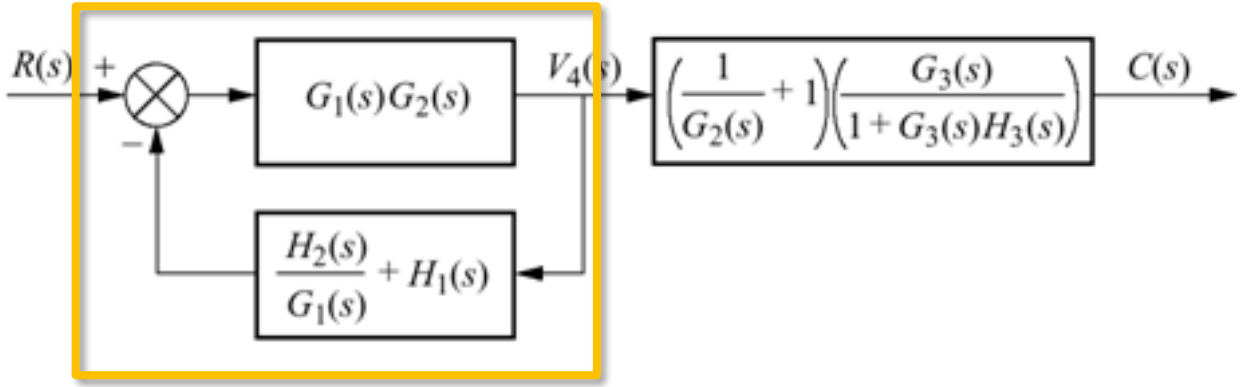


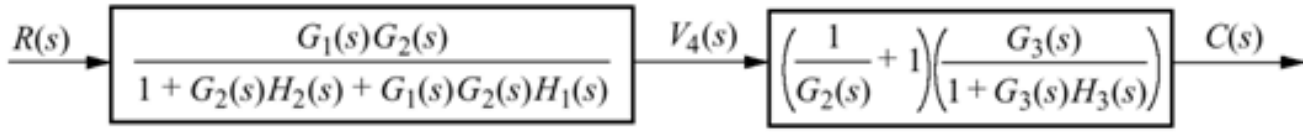

R(s)
V1(s)
G1(s)
V2(s)
V3(s)
G2(s)
V4(s)
V5(s)
G3(s)
C(s)
V7(s)
H2(s)
V8(s)
H3(s)
V6(s)
H1(s)

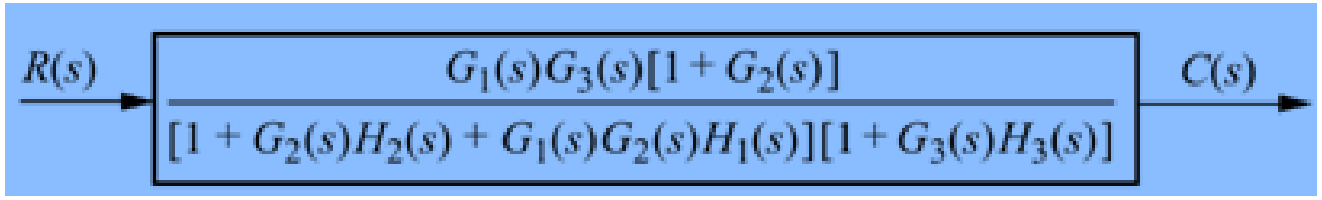

R(s)
G1(s)
G2(s)
1/G2(s)
G3(s)/(1 + G3(s)H3(s))
C(s)
V7(s)
H2(s)
V6(s)
H1(s)


R(s)
V1(s)
G1(s)G2(s)
H2(s)/G1(s)
1/G2(s) + 1
G3(s)/(1 + G3(s)H3(s))
C(s)
H1(s)

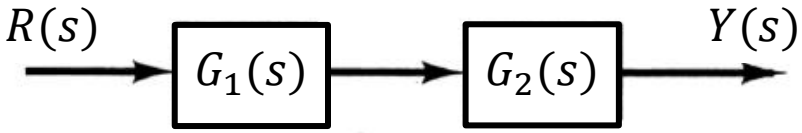

R(s)
V1(s)
G1(s)G2(s)
V4(s)
1/G2(s) + 1
G3(s)/(1 + G3(s)H3(s))
C(s)
H2(s)/G1(s)
H1(s)

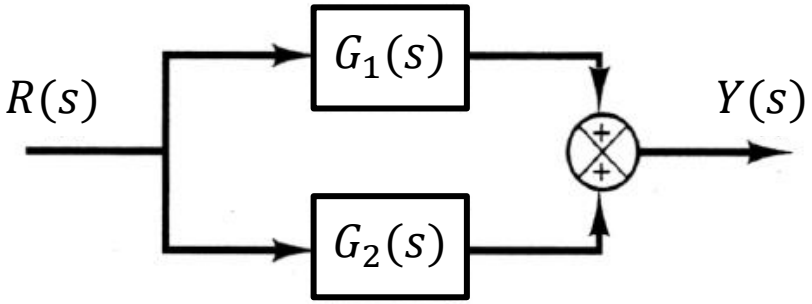

R(s)
G1(s)G2(s)
V4(s)
(1/G2(s) + 1)(G3(s)/(1 + G3(s)H3(s)))
C(s)
H2(s)/G1(s) + H1(s)

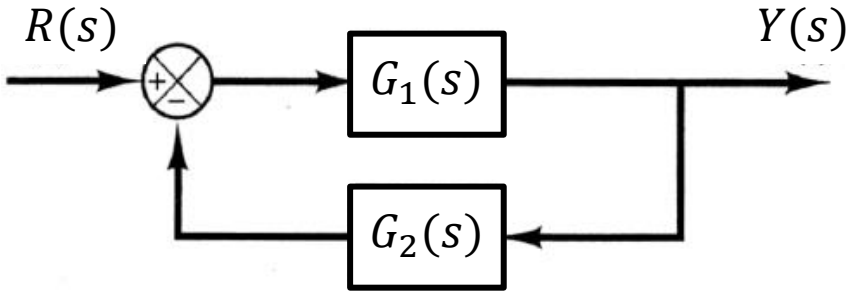

R(s)
G1(s)G2(s) / (1 + G2(s)H2(s) + G1(s)G2(s)H1(s))
V4(s)
(1/G2(s) + 1)(G3(s)/(1 + G3(s)H3(s)))
C(s)


R(s)
G1(s)G3(s)[1 + G2(s)] / [1 + G2(s)H2(s) + G1(s)G2(s)H1(s)][1 + G3(s)H3(s)]
C(s)

CASCATA, PARALELO E COM REALIMENTAÇÃO USANDO MATLAB/OCTAVE







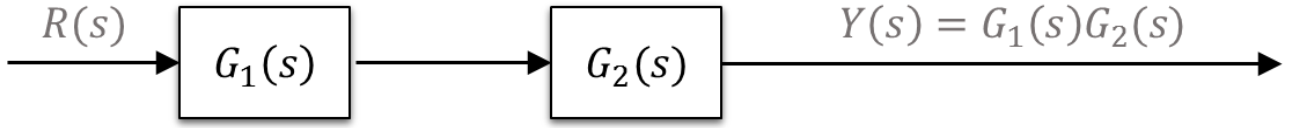
$$G_1(S) = \frac{num1}{den1}$$

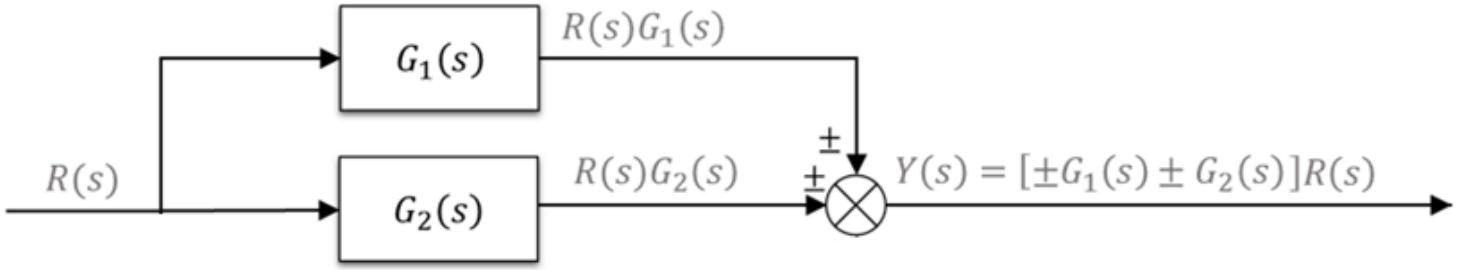
$$G_2(S) = \frac{num2}{den2}$$

Matlab ou Octave

```
[num, den] = series(num1,den1,num2,den2)
[num, den] = parallel(num1,den1,num2,den2)
[num, den] = feedback(num1,den1,num2,den2)
```

MALHA ABERTA – SISTEMAS EM SÉRIE E PARALELO






```
%% Malha aberta
num1=[10]; den1= [1 2 10];
num2=[5]; den2=[1 5];
sys1=tf(num1,den1); sys2=tf(num2,den2);
%malha aberta - sistemas em serie
G1G2serie=series(sys1,sys2)
%malha aberta - sistemas em paralelo
G1G2parallel=parallel(sys1,sys2)
```

As funções de transferência são,

$$G_1(s) = \frac{10}{s^2 + 2s + 10} = \frac{num1}{den1}$$

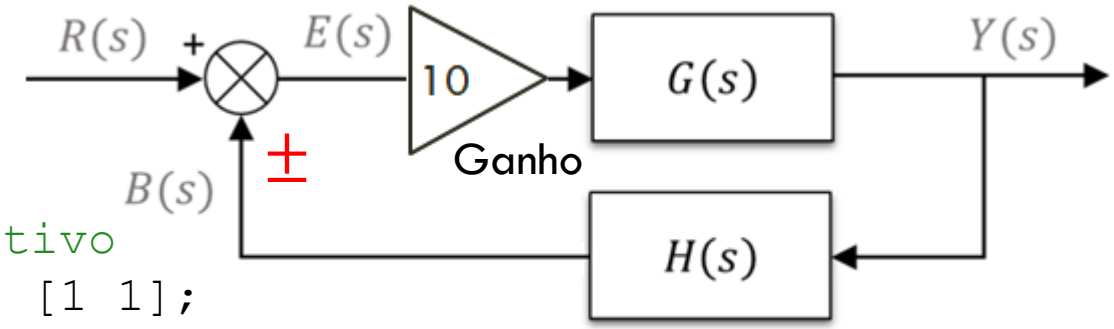
$$G_2(s) = \frac{5}{s + 5} = \frac{num2}{den2}$$

SISTEMA COM FEEDBACK

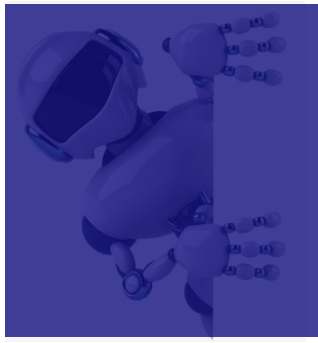
```
>> sys = feedback(sys1,sys2)        para feedback negativo
>> sys = feedback(sys1,sys2,+1)     para feedback positivo
```

$$G(s) = \frac{1}{s+1} = \frac{num1}{den1} = sys1$$

$$H(s) = \frac{1}{s+2} = \frac{num2}{den2} = sys2$$



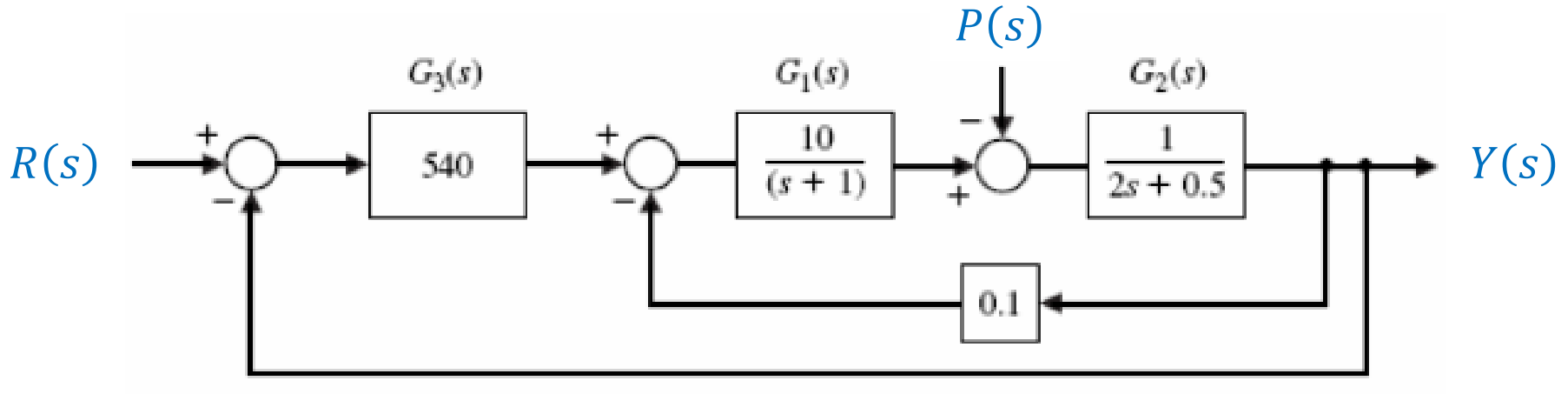

```
%%Malha fechada
% feedback positivo
num1=[1]; den1= [1 1];
num2=[1]; den2=[1 2];
sys1=tf(num1,den1); sys2=tf(num2,den2)
FeedPos = feedback(10*sys1,sys2,+1)
% feedback negativo
FeedNeg = feedback(10*sys1,sys2)
```



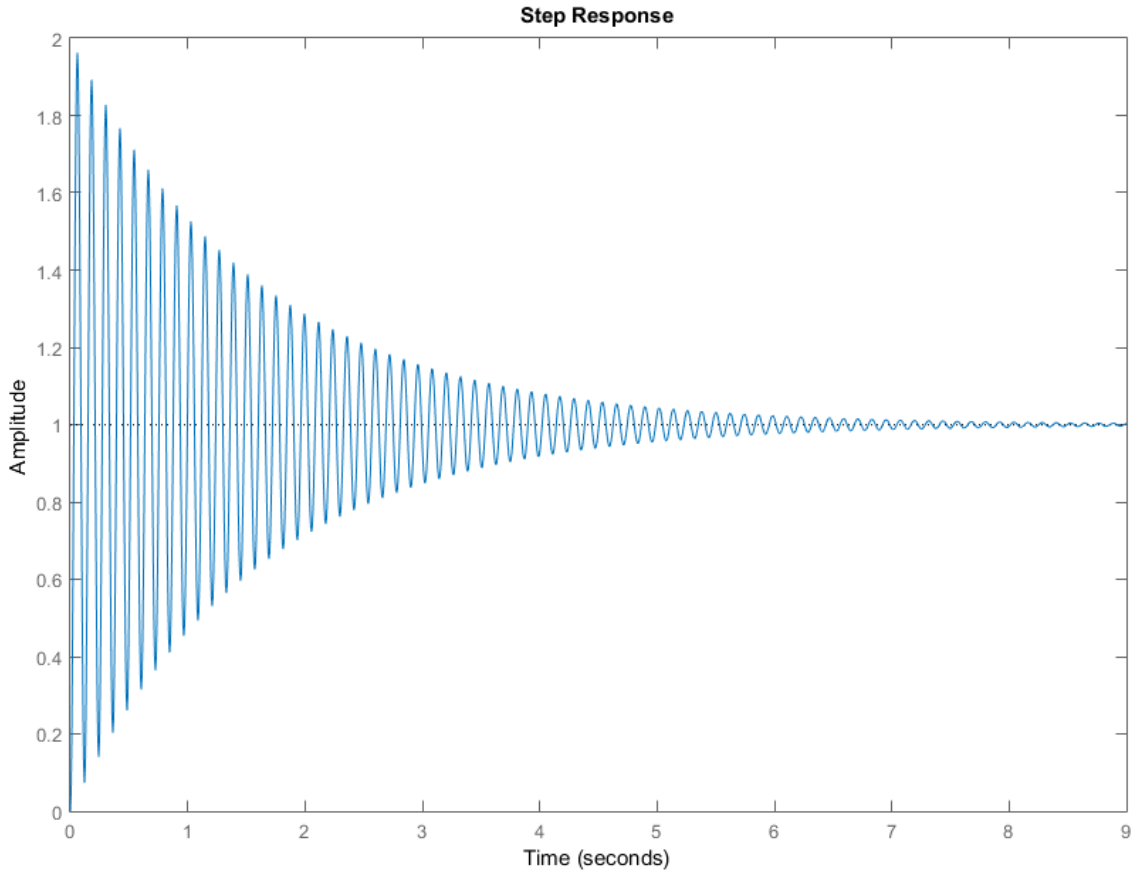
ESTUDO DE CASO I

APLICAÇÃO

- Com ajuda do Octave, ache a saída $Y(s)$ do sistema abaixo. Analise a resposta para uma entrada degrau, com perturbação nula.

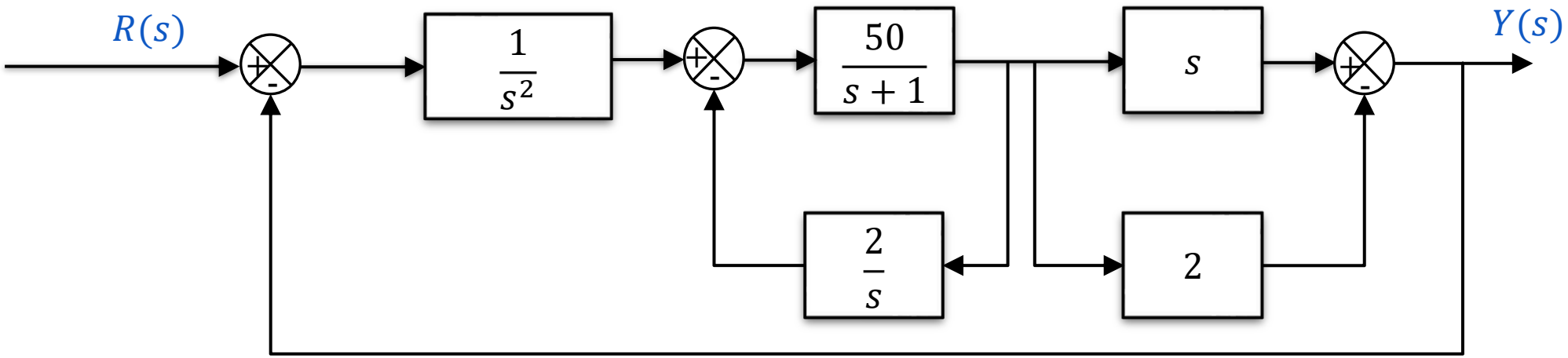


```
close all; clear all; clc
num1=[10]; den1= [1 1];
num2=[1]; den2=[2 0.5];
sys1=tf(num1,den1); sys2=tf(num2,den2);
sys3=tf(540,1); sys4=tf(0.1,1);
G_1=feedback(series(sys3,feedback(series(sys1,sys2),sys4)),1)

syms s
g1=10/(s+1); g2=1/(2*s+0.5); g3=540; g4=0.1;
G_2=g1*g2*g3/(1+g1*g2*g3+0.1*g1*g2);
simplify(G_2)

step(G_1)
```



TAREFA

Com ajuda do Octave, ache a função de transferência $Y(s)/X(s)$ do sistema abaixo. Qual a resposta a uma função degrau?



FIM DO SEXTO MÓDULO

John C. Bogle says:
Learn every day, but especially from the experiences of others. It's cheaper!