Lecture 2

Topics Covered

Block Diagram Reduction Technique

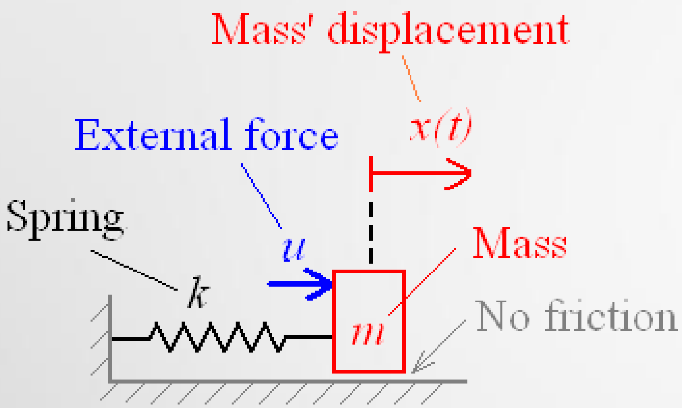
Block Diagram

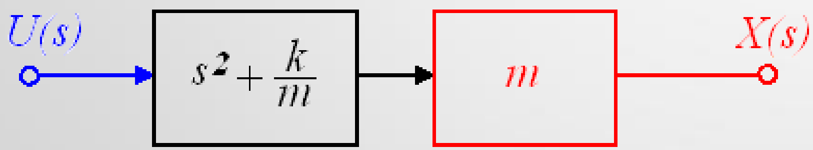
- It represents the structure of a control system.
- It helps to organize the variables and equations representing the control system.

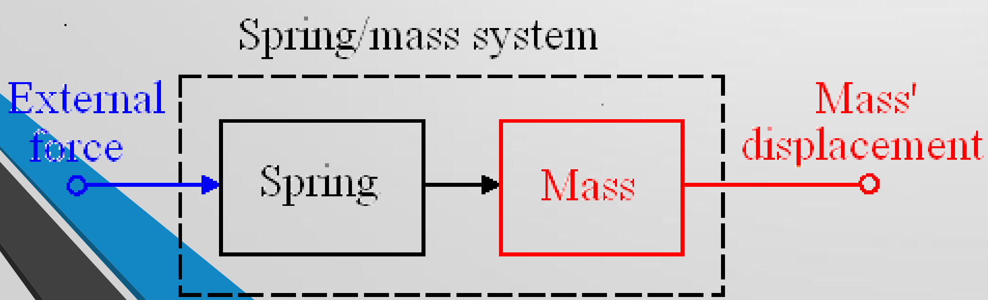
It is composed of:

- boxes, that represents the components of the system including their causality;
- Lines with arrows, that represent the actual dynamic variables, such as *speed*, *pressure*, *velocity*, etc..

Simplest Open-Loop Control Example & Associated Block Diagrams

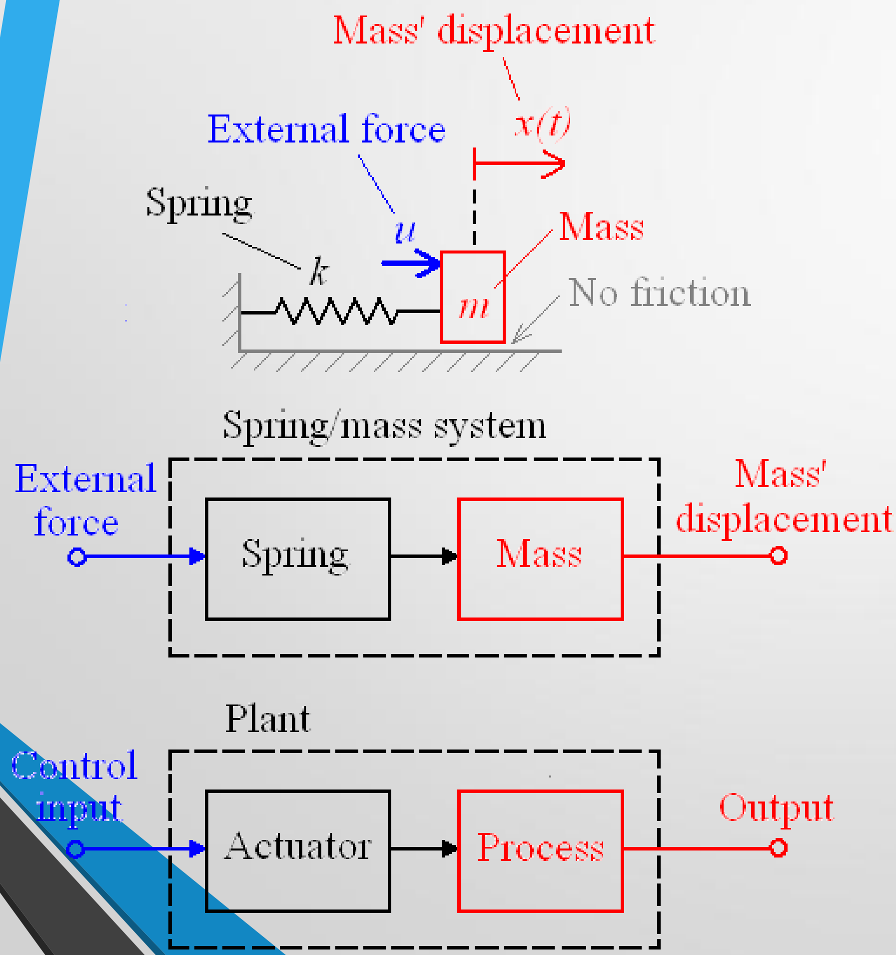






- *System* = mass + spring
- *Control Input*: force *u*
- *Output*: displacement *x(t)*
- *Block diagram* (derived using Laplace transforms, more on this later)
- *Component block diagram* for the system examined

Specific & Generic Component Block Diagrams



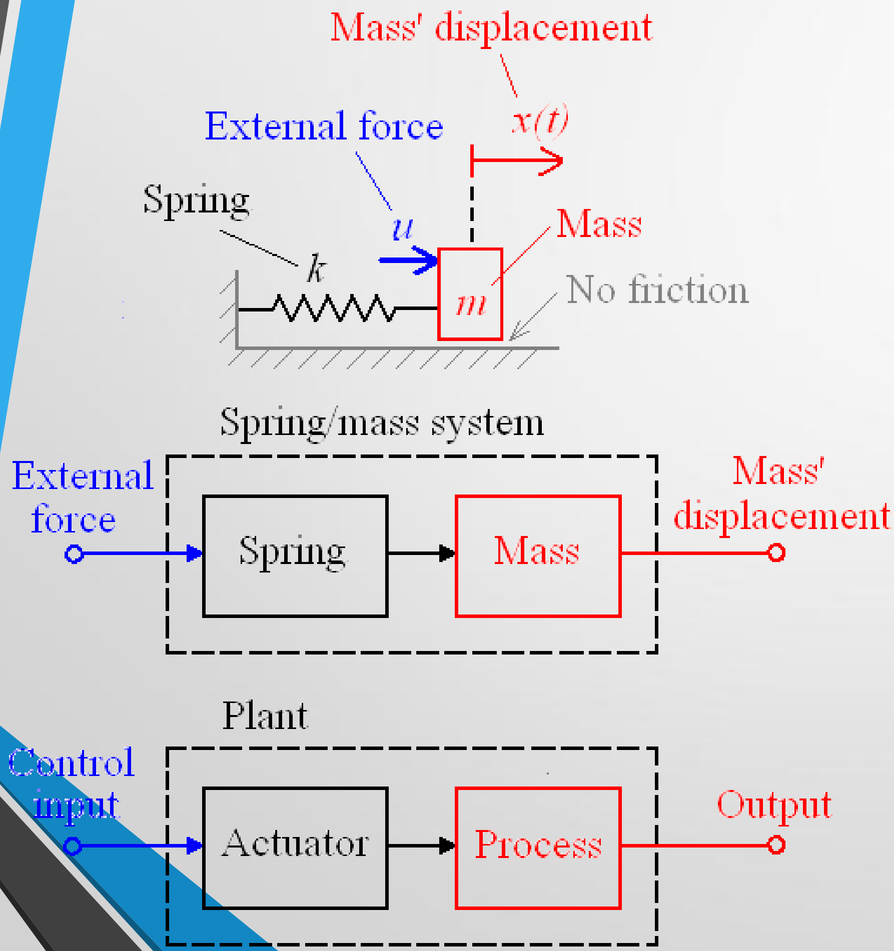
Recall previous system

- *Control Input*: force *u*
- *Output*: displacement *x(t)*

Component block diagram for the system examined

Generic component block diagram

Definitions of Process, Actuator & Plant



- **Process** = component whose the output is to be controlled

  Ex: *Mass*

- **Actuator** = device that can influence the control input variable of the process

  Ex: *Spring*

- **Plant** = actuator + process

  Ex: *Spring/mass system*

Figure 2.2

Components of a block diagram f

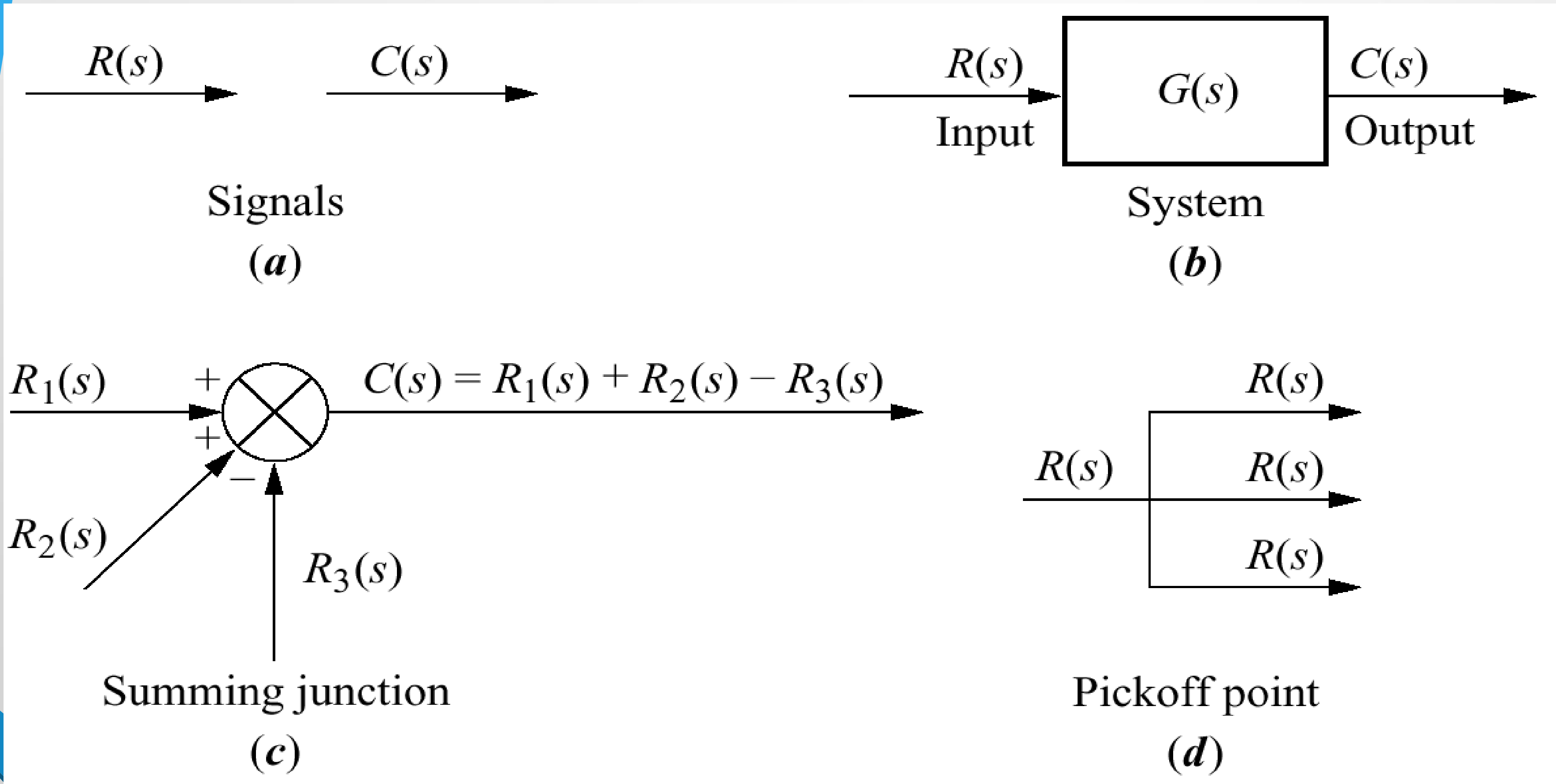


Figure 2.3
a. Cascaded subsystems;
b. equivalent transfer function

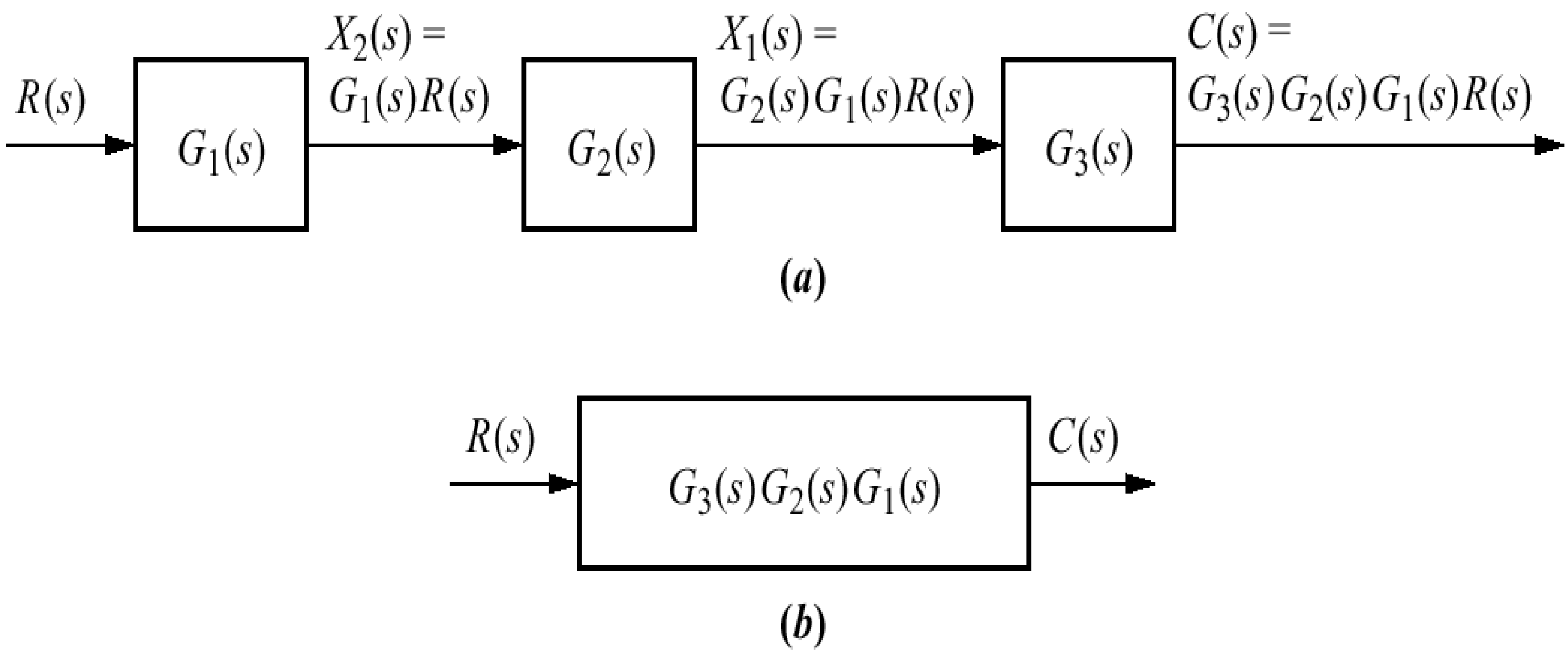


Figure 2.4
Loading in cascaded systems

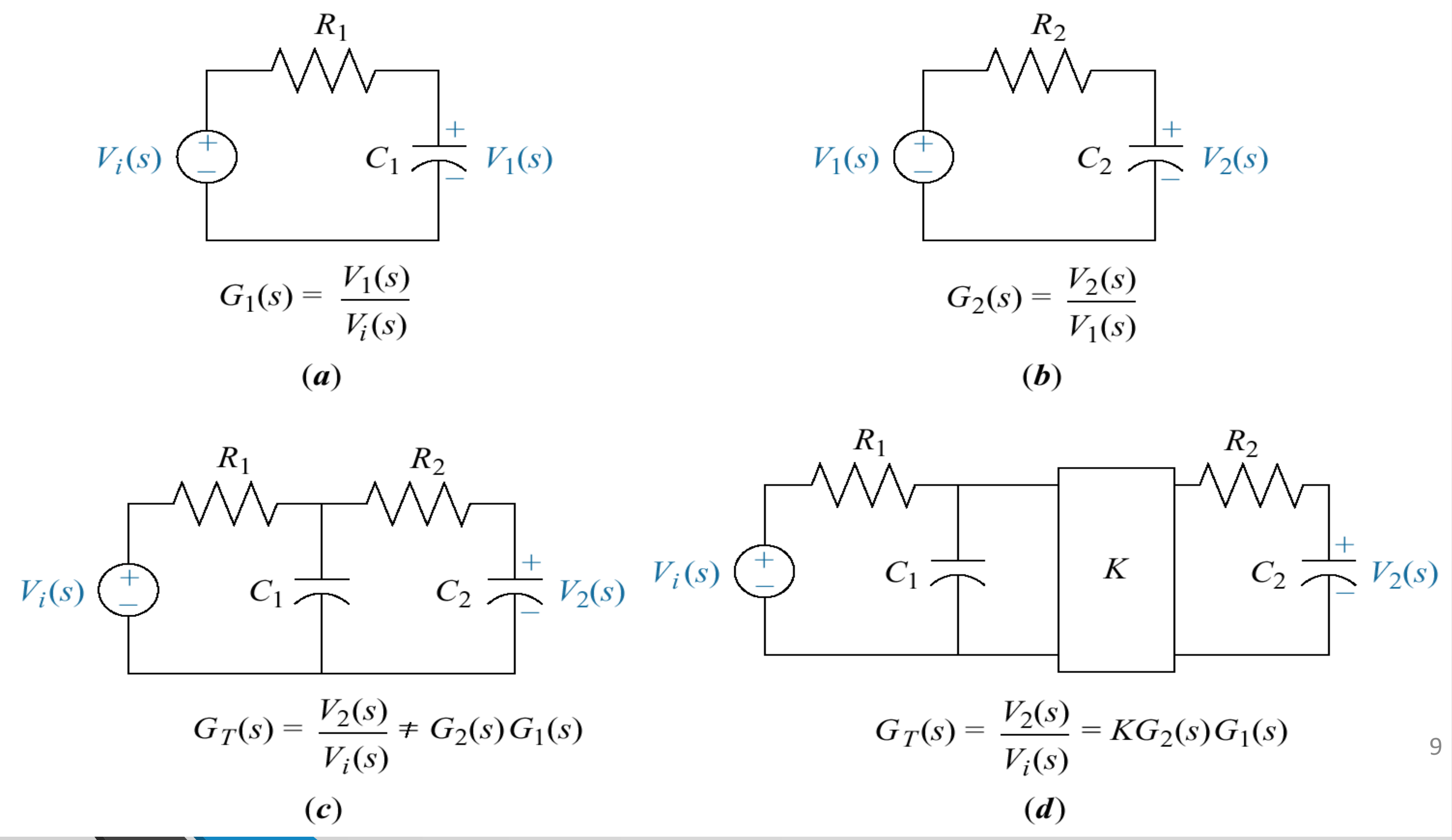


Figure 2.5
a. Parallel subsystems;
b. equivalent transfer function

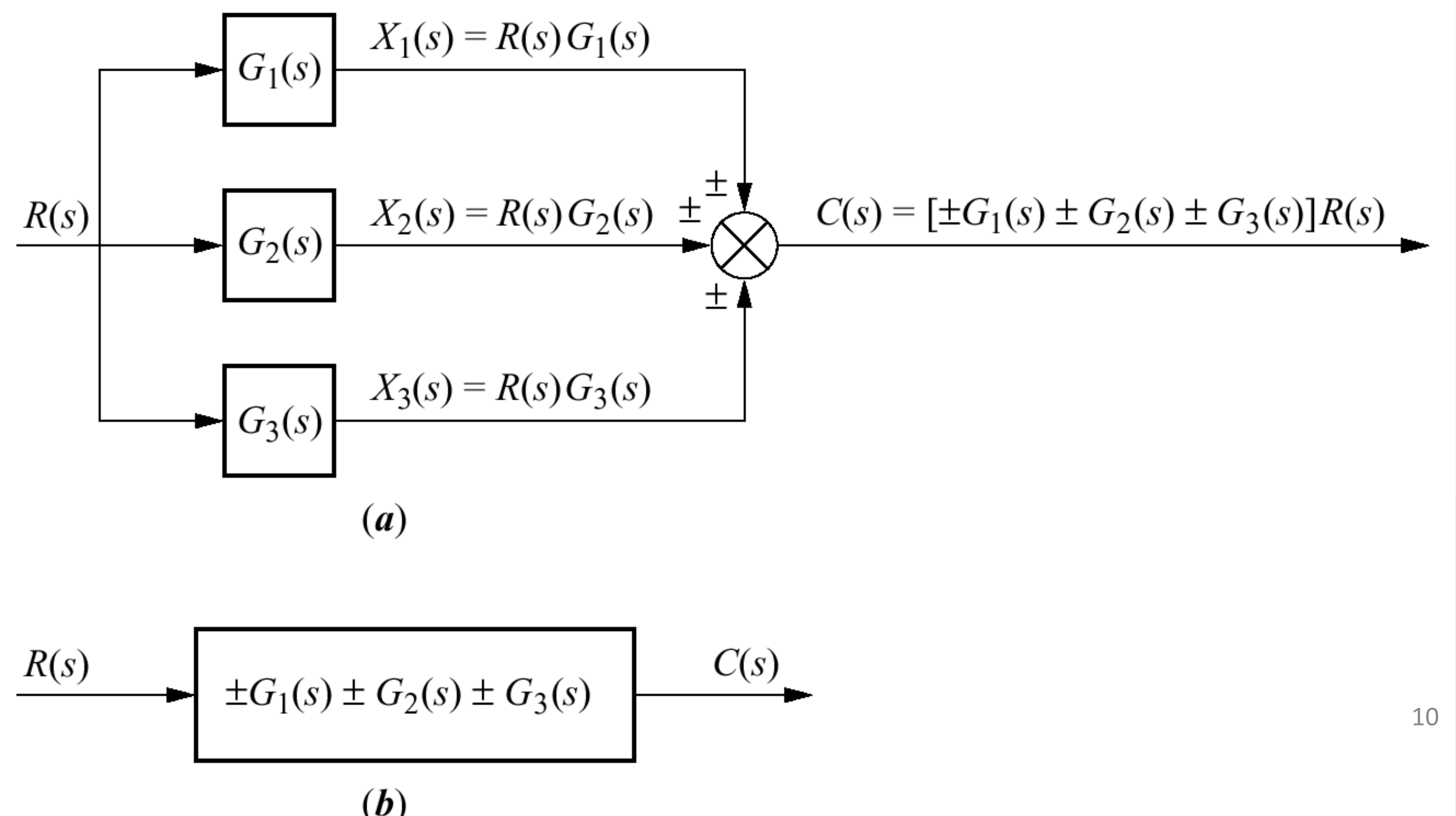


Figure 2.6

a. Feedback control system;
b. simplified model;
c. equivalent transfer function

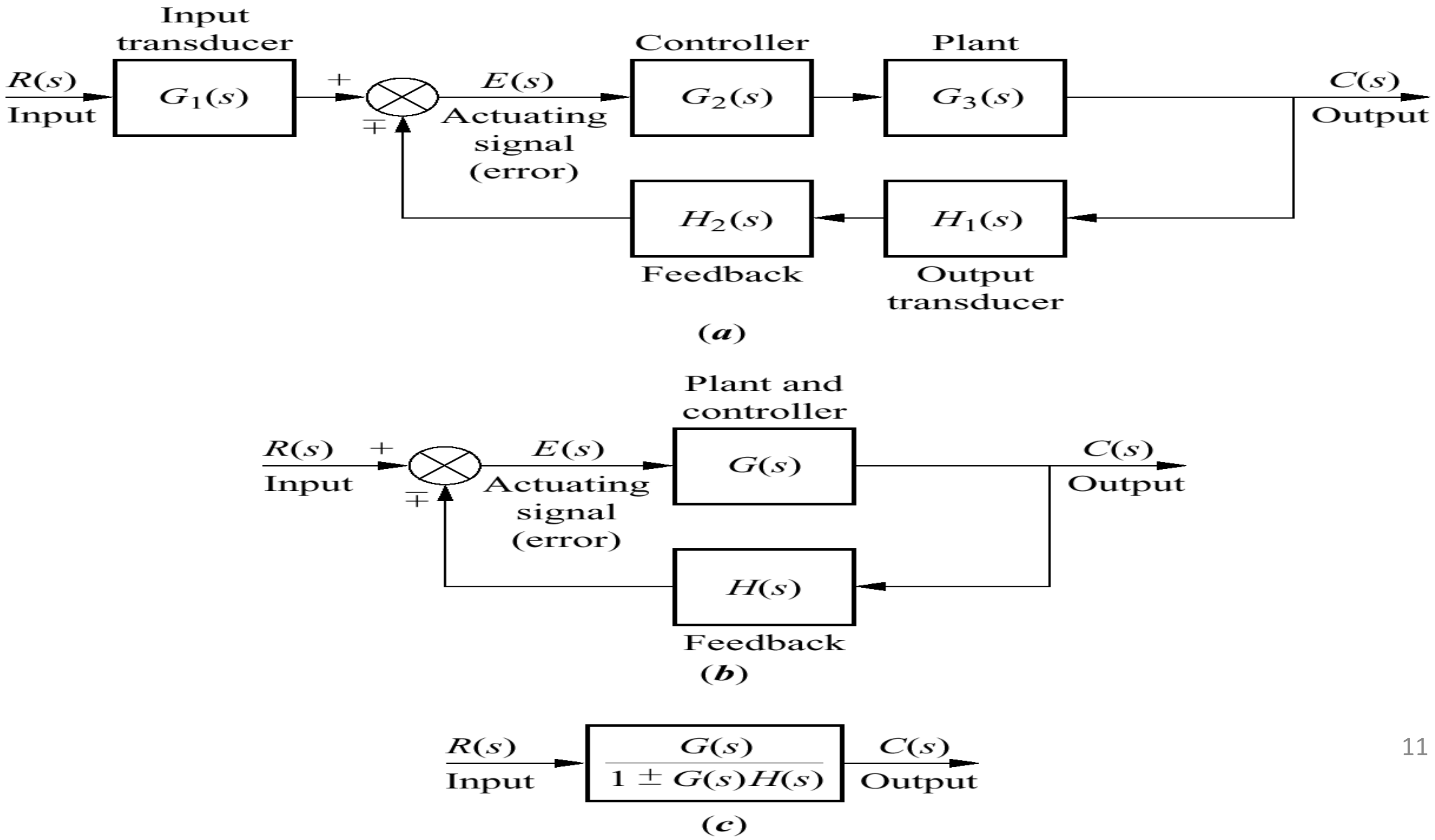


Figure 2.7

Block diagram algebra for summing junctions—
a. to the left past a summing junction;
b. to the right past a summing junction

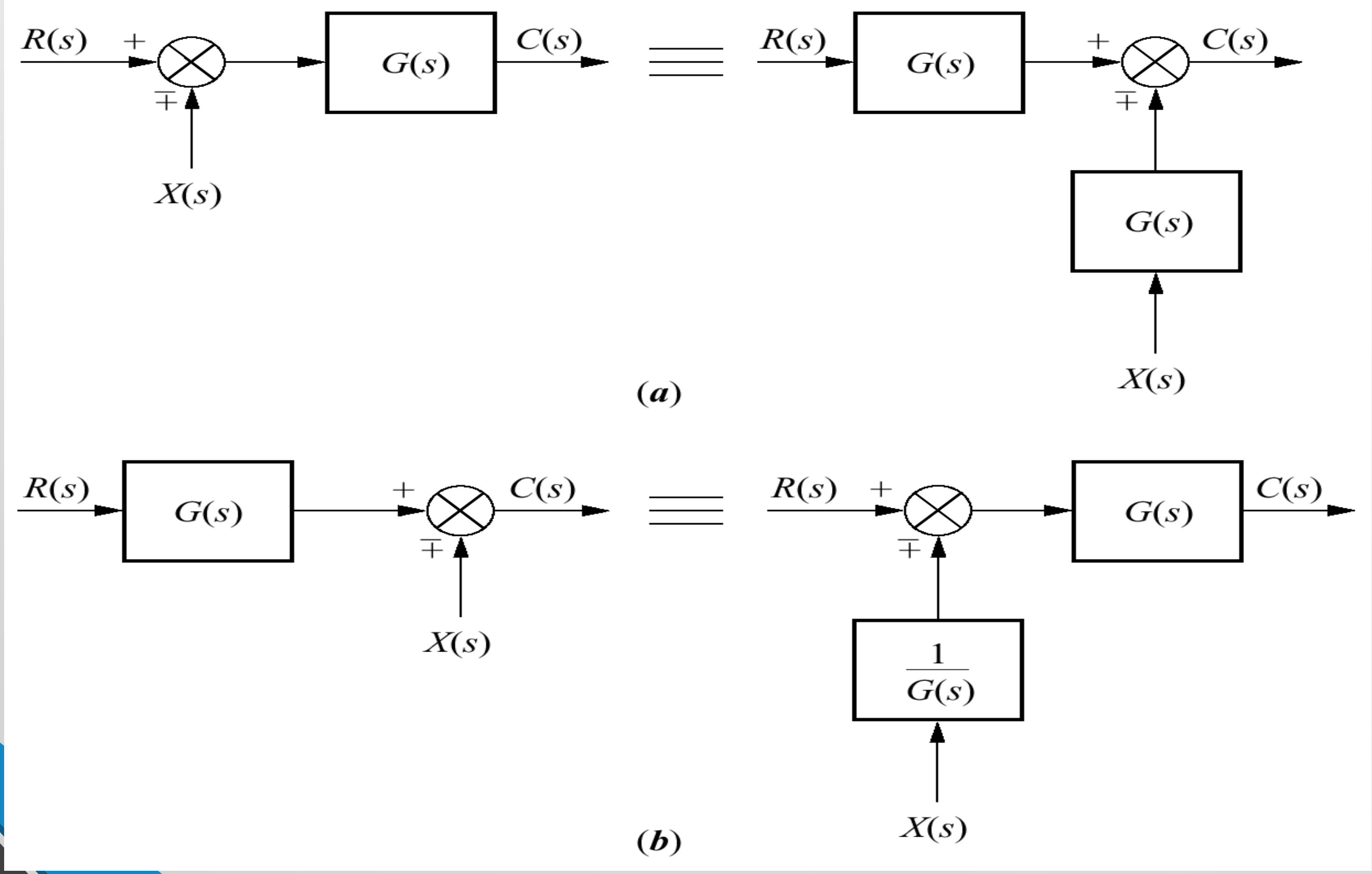


Figure 2.8

Block diagram algebra for pickoff points—equivalent forms for moving a block

a. to the left past a pickoff point;

b. to the right past a pickoff point

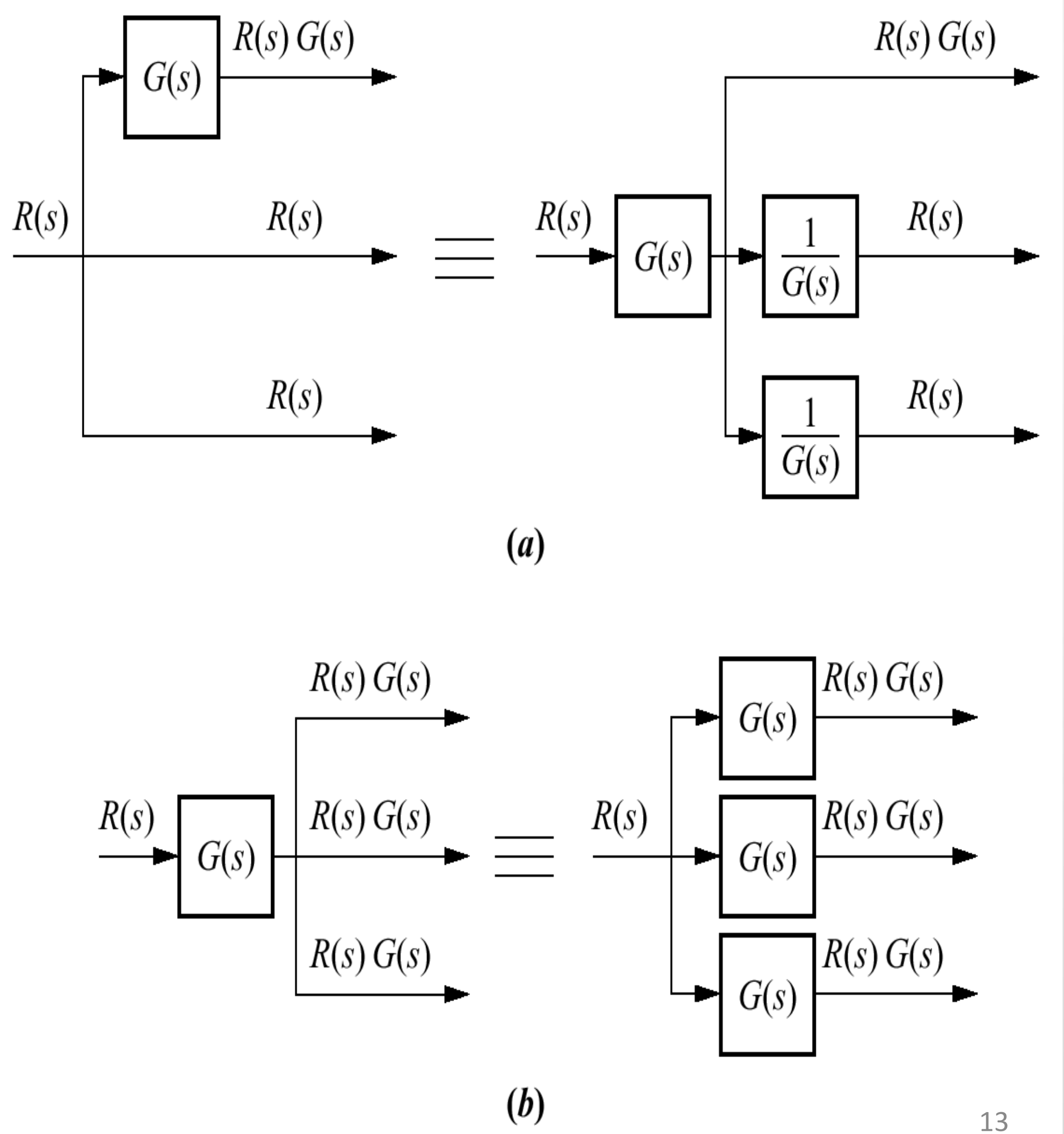


Figure 2.9
Block diagram for Example5.1

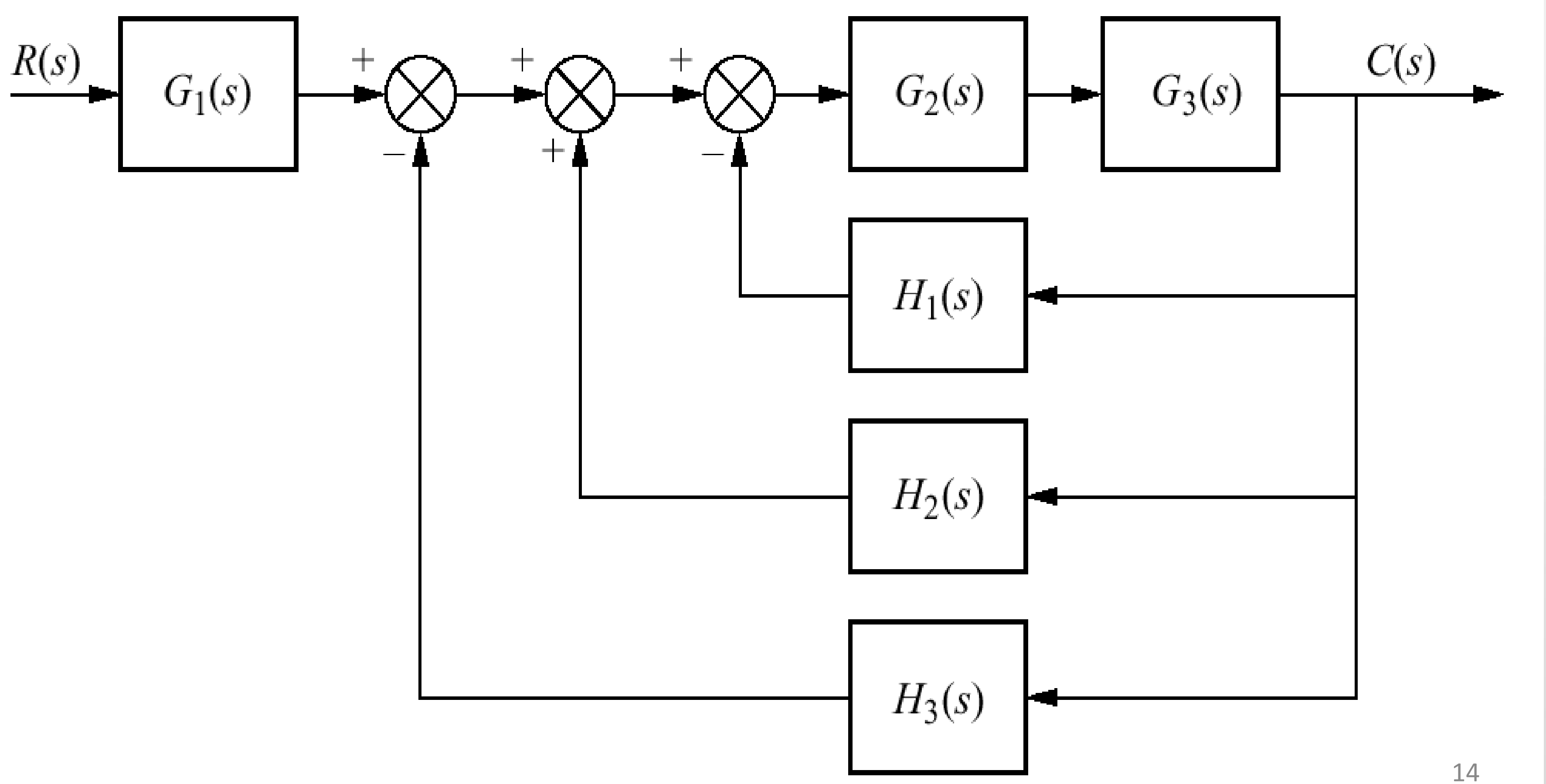


Figure 2.10

Steps in solving Example 5.1:
a. collapse summing junctions;
b. form equivalent cascaded system in the forward path and equivalent parallel system in the feedback path;
c. form equivalent feedback system and multiply by cascaded $G_1(s)$

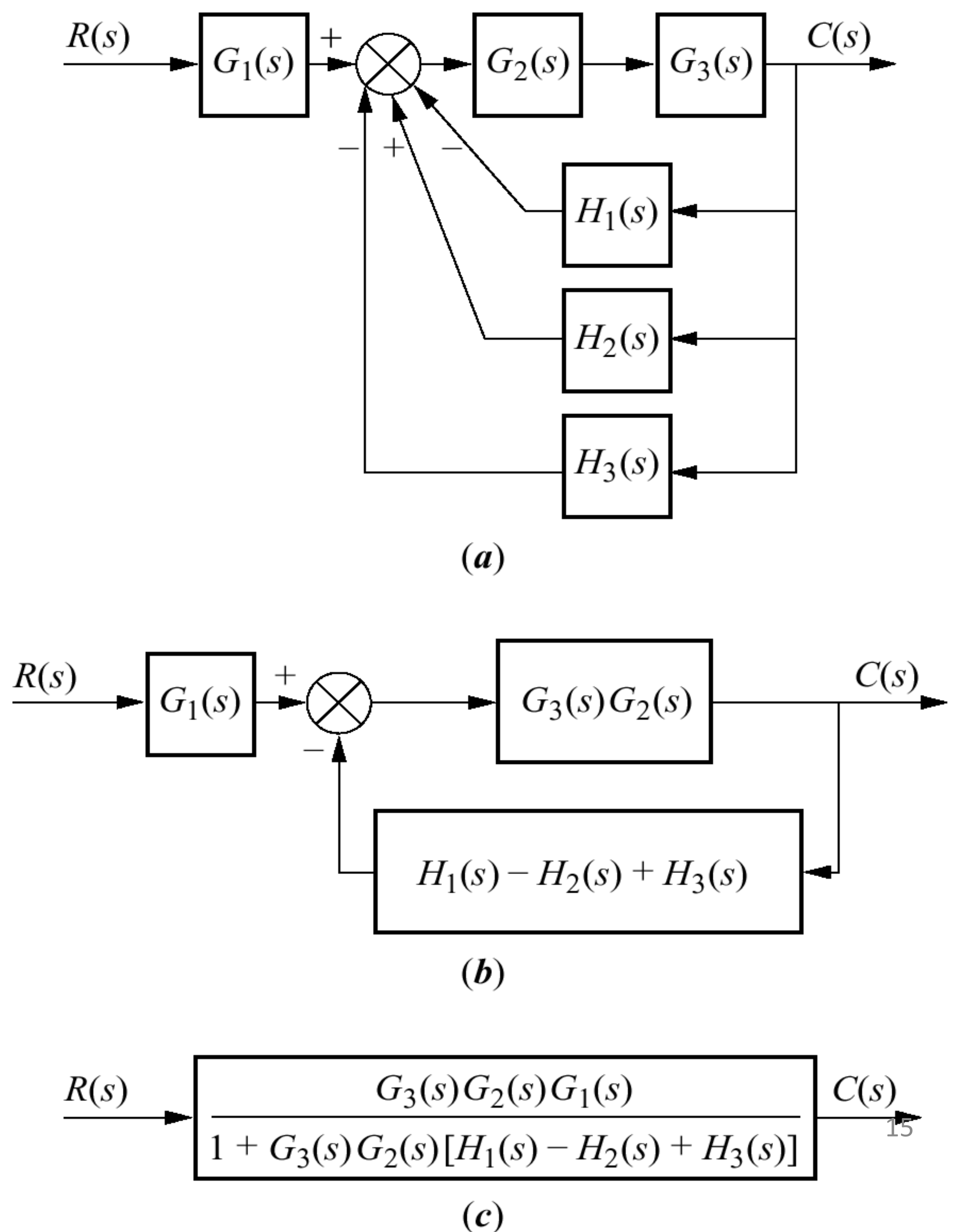
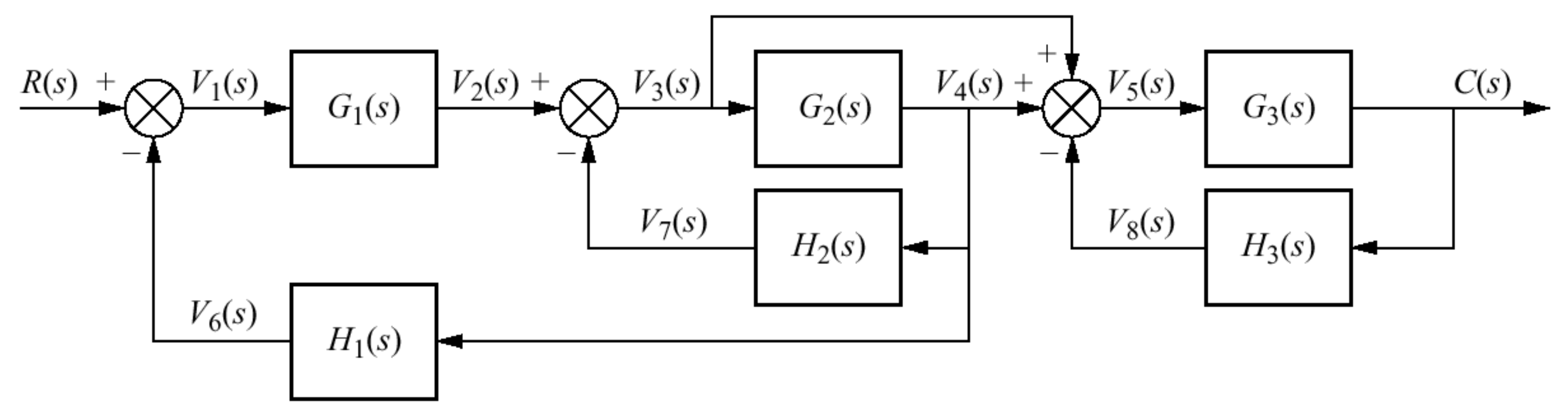
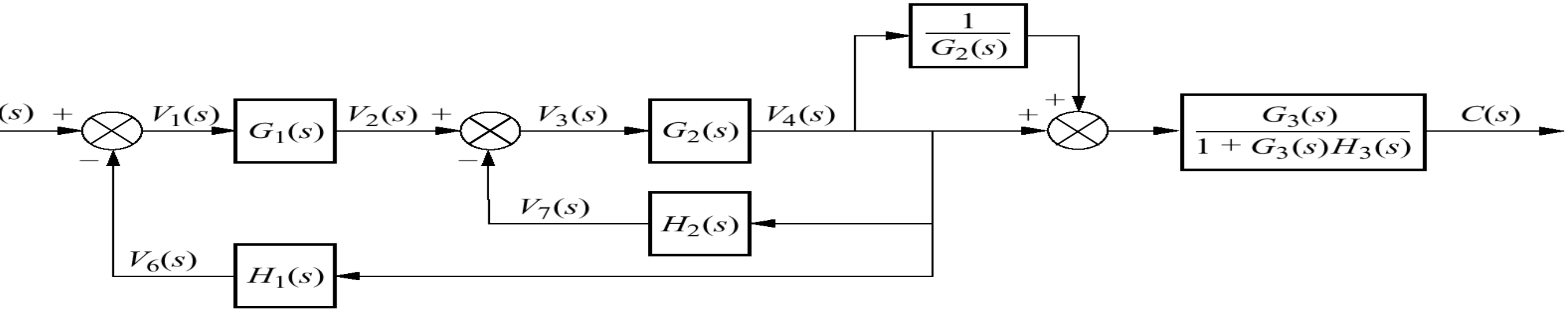


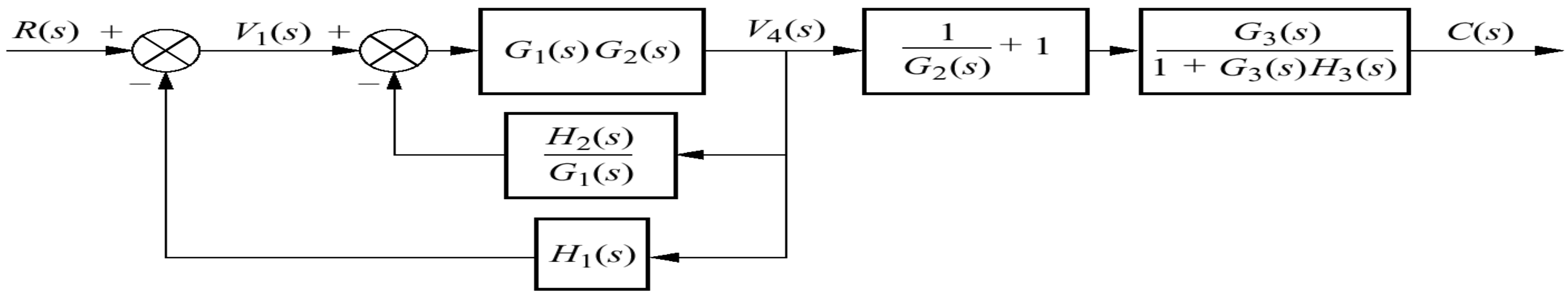
Figure 2.11
Block diagram for Example 5.2





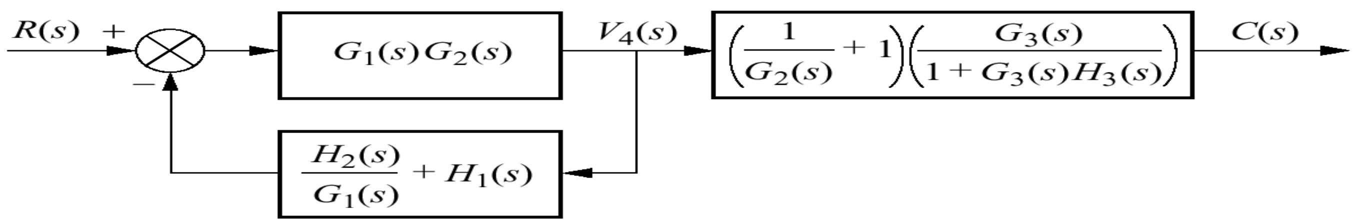
(s) +
$-$
$V_1(s)$
$G_1(s)$
$V_2(s)$ +
$-$
$V_3(s)$
$G_2(s)$
$V_4(s)$
$\frac{1}{G_2(s)}$
+
+
$\frac{G_3(s)}{1+G_3(s)H_3(s)}$
$C(s)$
$V_7(s)$
$H_2(s)$
$V_6(s)$
$H_1(s)$

(*a*)



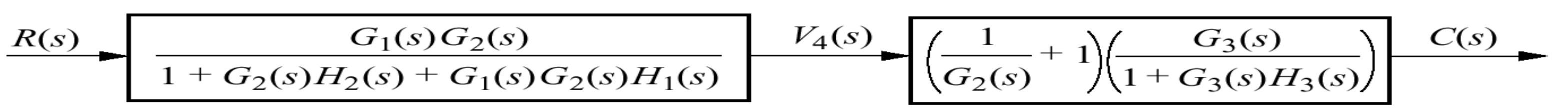
$R(s)$ +
$-$
$V_1(s)$ +
$-$
$G_1(s)G_2(s)$
$V_4(s)$
$\frac{1}{G_2(s)}+1$
$\frac{G_3(s)}{1+G_3(s)H_3(s)}$
$C(s)$
$\frac{H_2(s)}{G_1(s)}$
$H_1(s)$

(*b*)



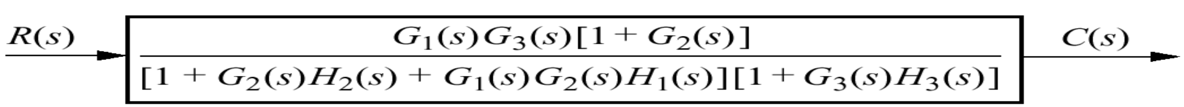
$R(s)$ +
$-$
$G_1(s)G_2(s)$
$V_4(s)$
$\left(\frac{1}{G_2(s)}+1\right)\left(\frac{G_3(s)}{1+G_3(s)H_3(s)}\right)$
$C(s)$
$\frac{H_2(s)}{G_1(s)}+H_1(s)$

(*c*)



$R(s)$
$\frac{G_1(s)G_2(s)}{1+G_2(s)H_2(s)+G_1(s)G_2(s)H_1(s)}$
$V_4(s)$
$\left(\frac{1}{G_2(s)}+1\right)\left(\frac{G_3(s)}{1+G_3(s)H_3(s)}\right)$
$C(s)$

(*d*)



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

(*e*)