Block diagram Reduction Technique

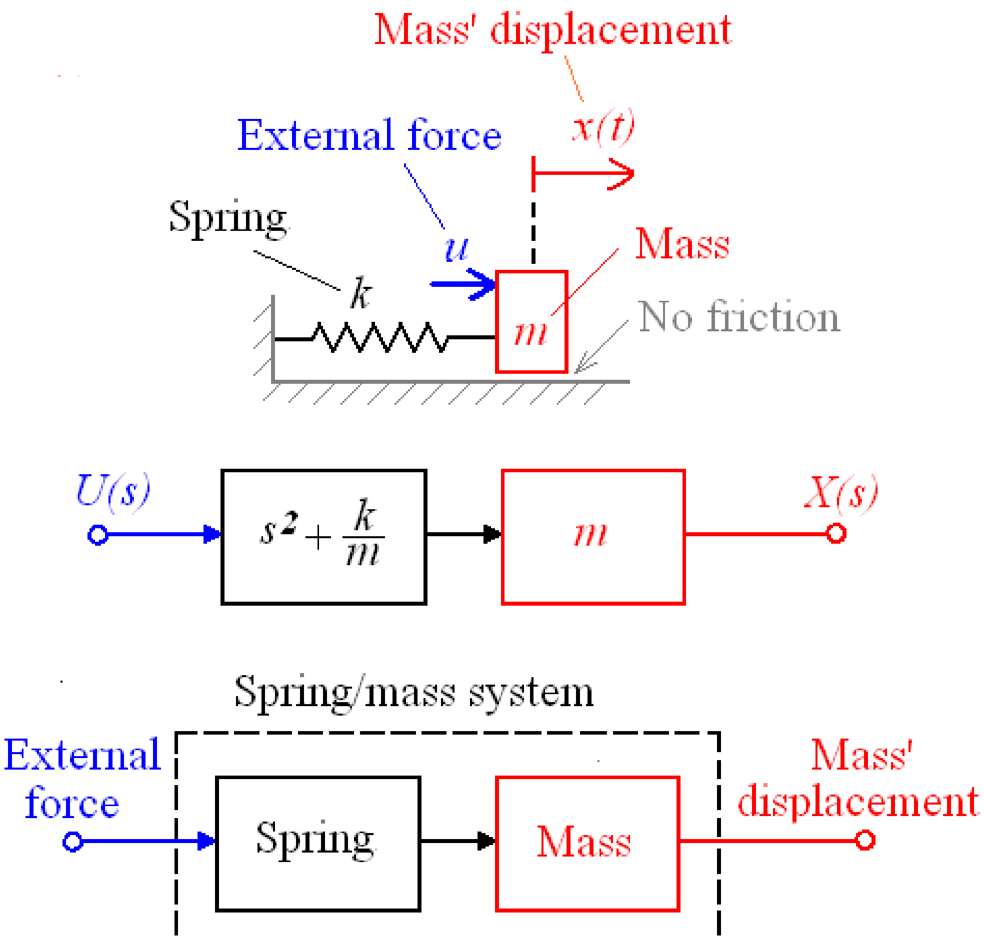
Block Diagram

- 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

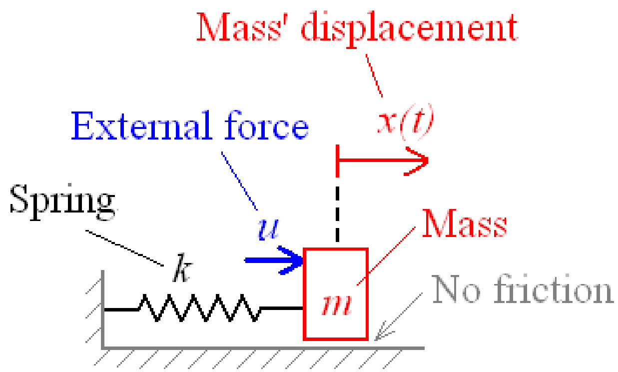


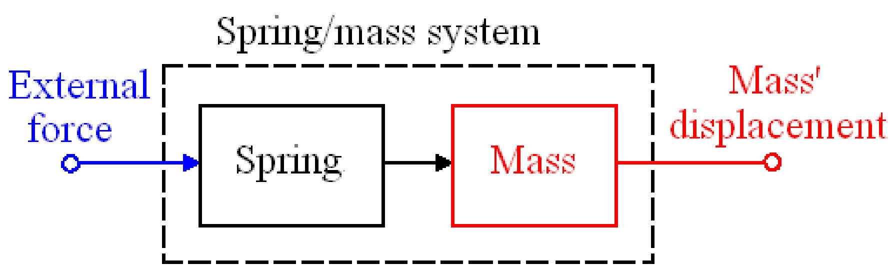
- *System* = mass + spring
- *Control Input*: force *u*
- *Output*: displacement *x(t)*

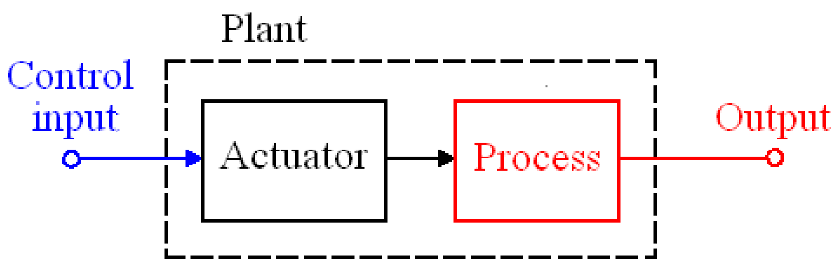
- *Block diagram* (derived using Laplace transforms, more on this later)

- *Component block diagram* for the system examined

Specific & Generic Component Block Diagrams







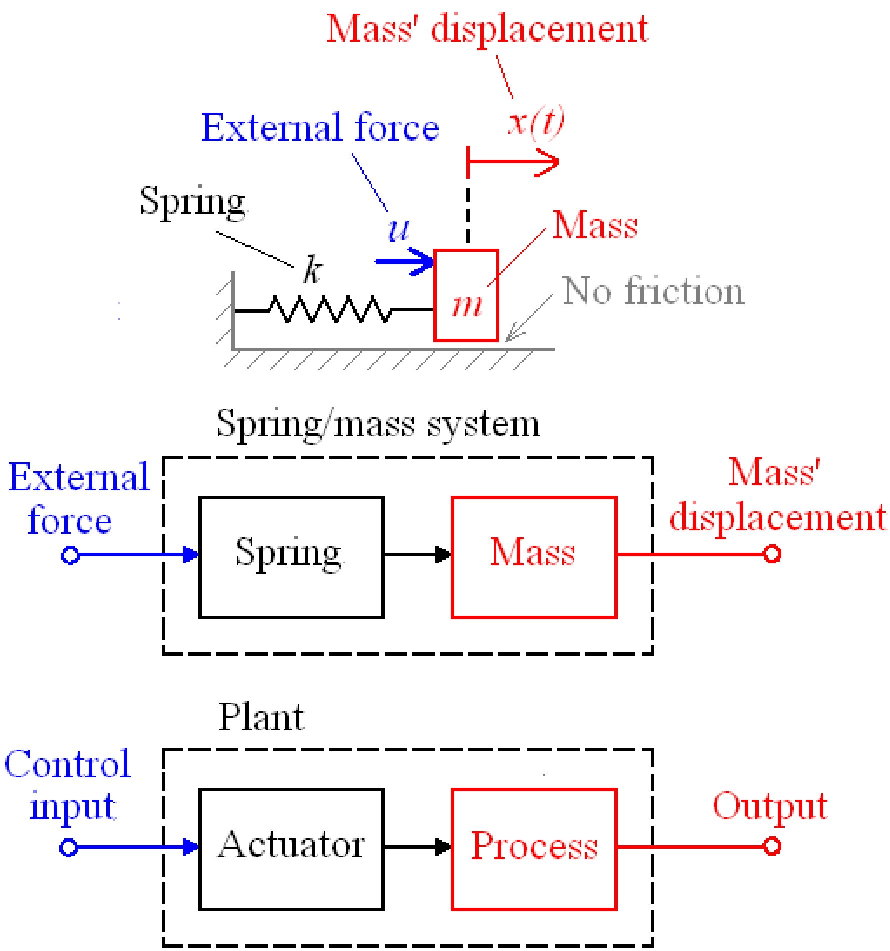
Recall previous system

- *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

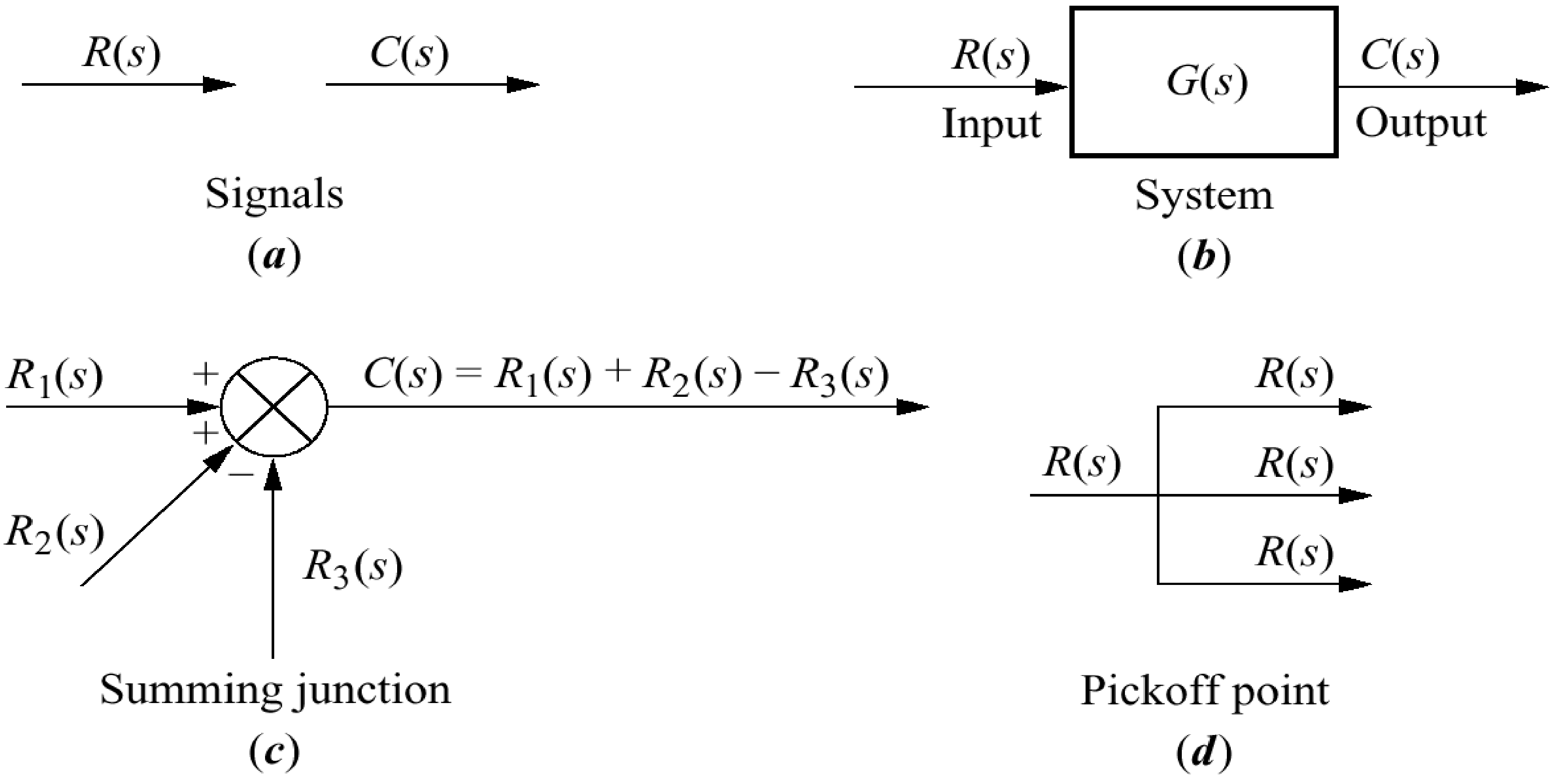


Figure 2.3
a. Cascaded subsystems;
b. equivalent transfer function

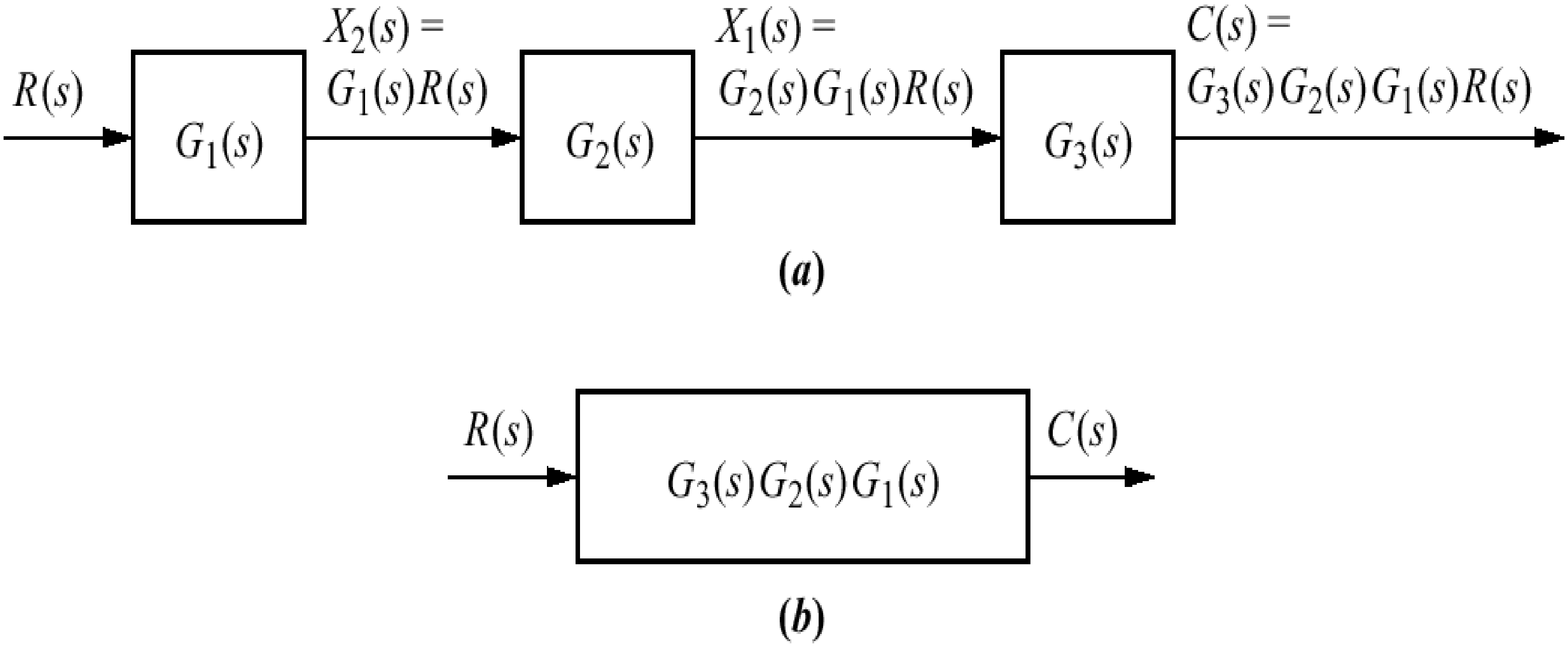


Figure 2.4
Loading in cascaded systems

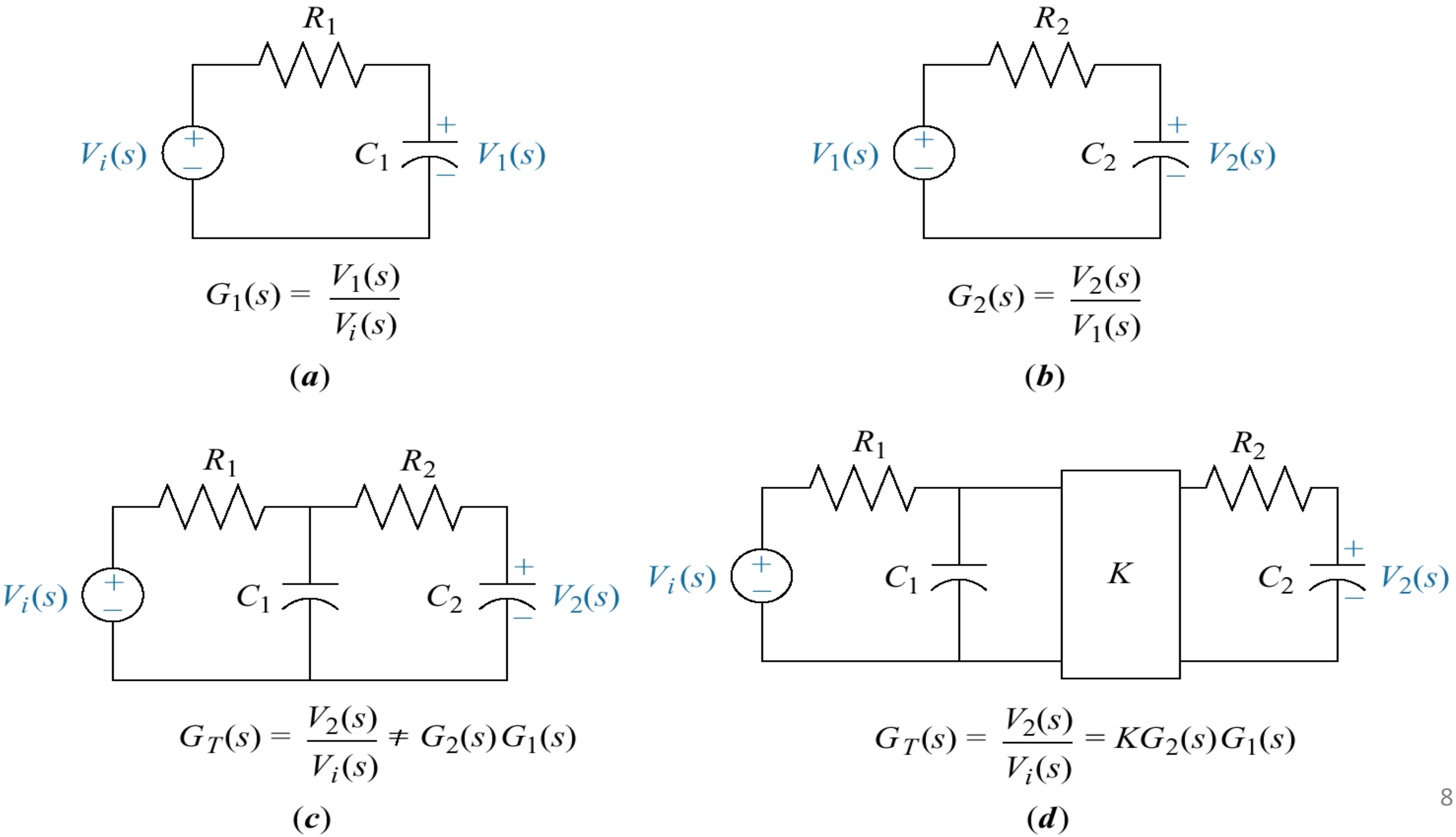
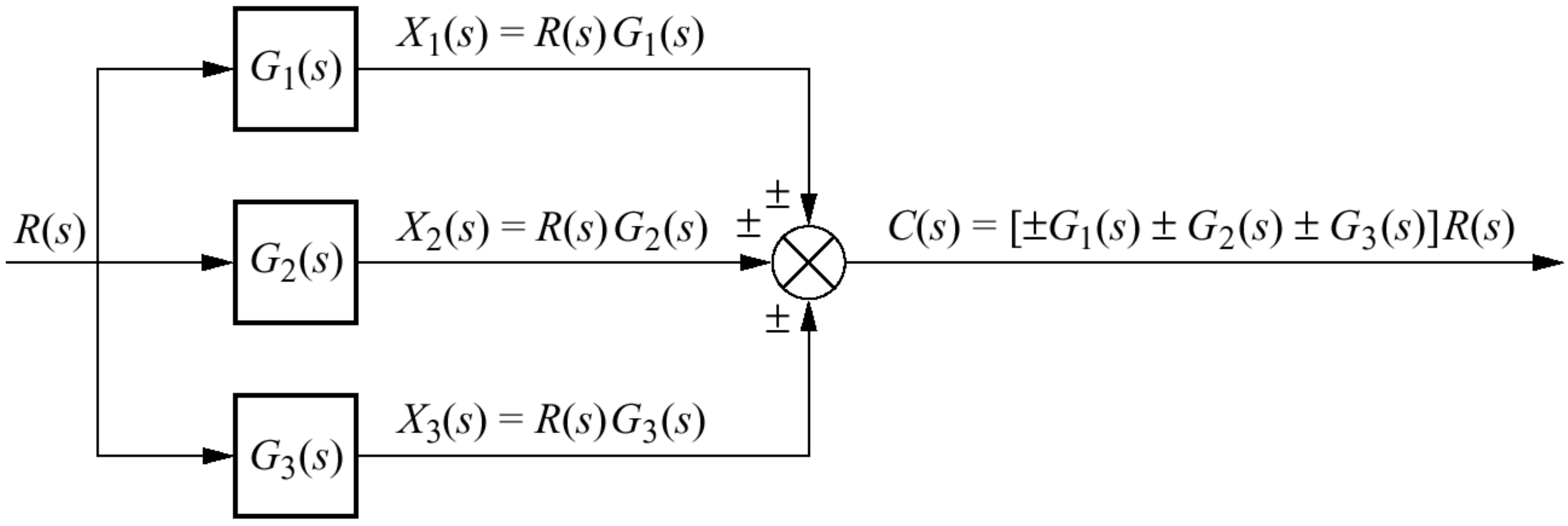
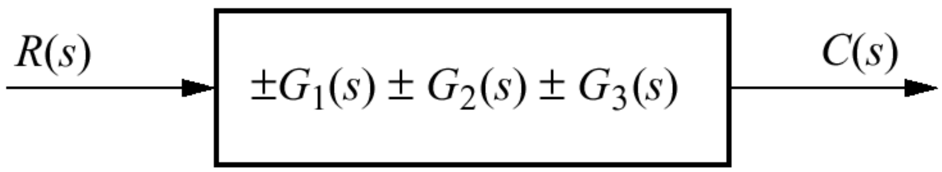


Figure 2.5
a. Parallel subsystems;
b. equivalent transfer function



(*a*)



(*b*)

Figure 2.6

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

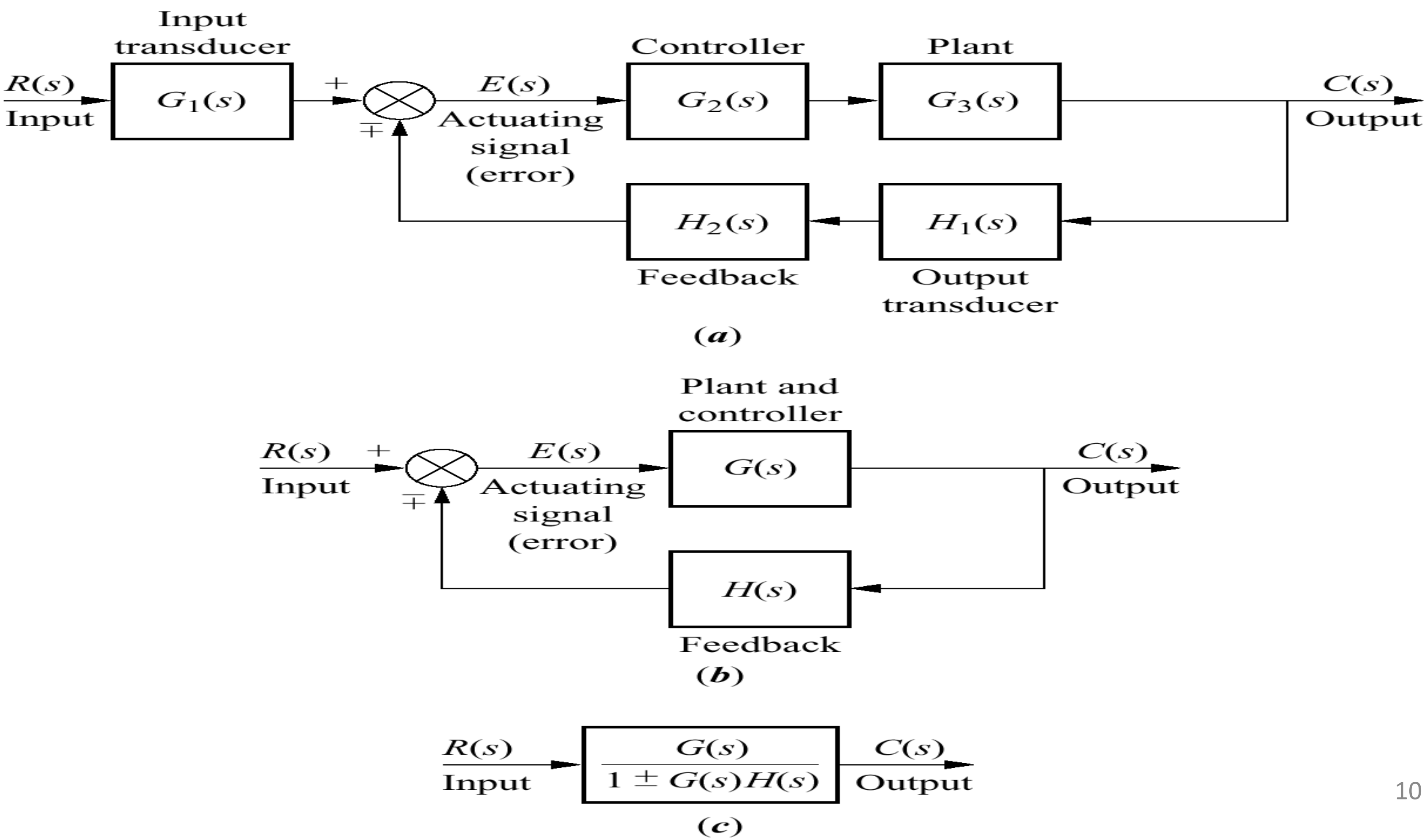


Figure 2.7

Block diagram algebra for summing junctions—

a. to the left past a summing junction;

b. to the right past a summing junction

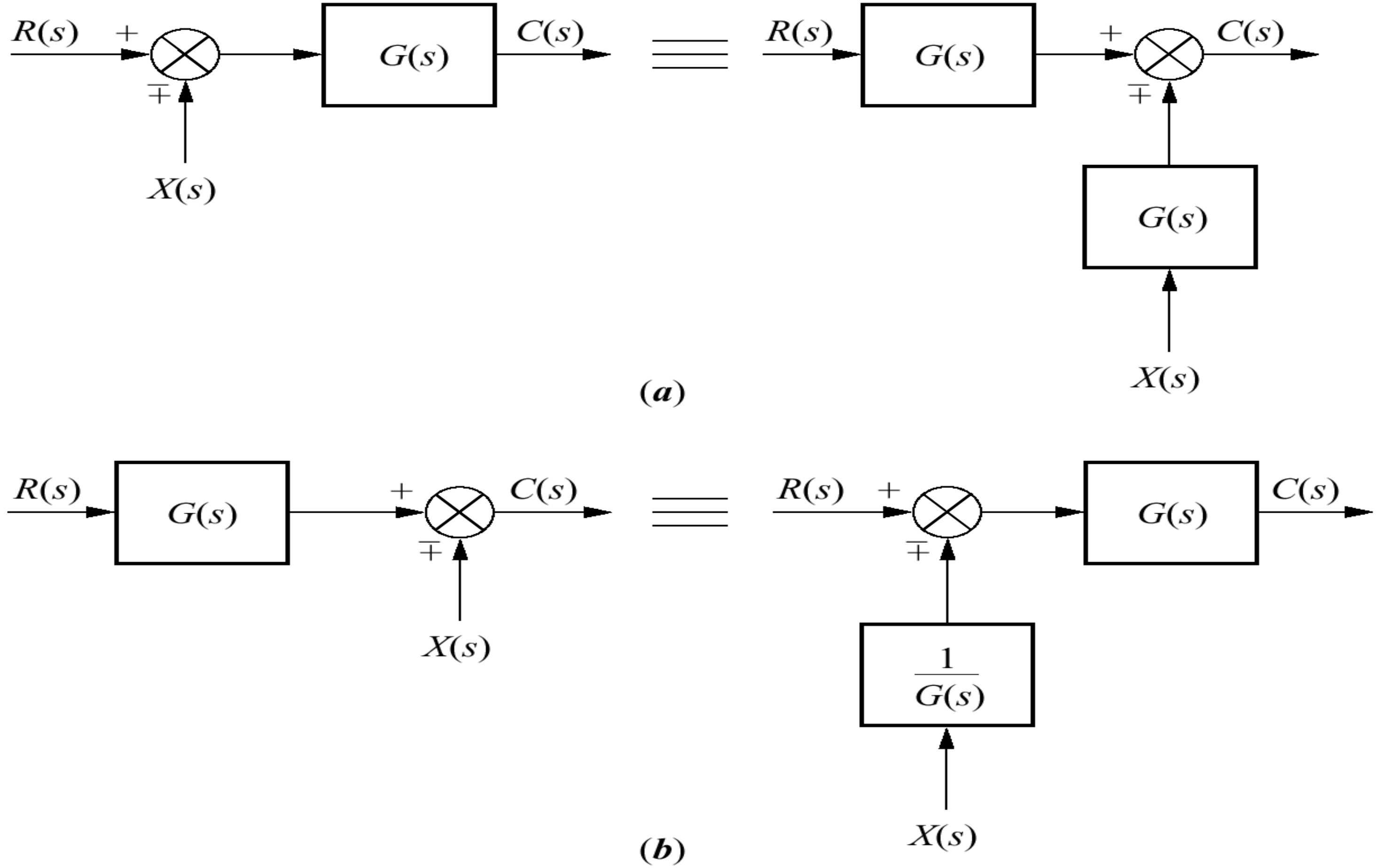
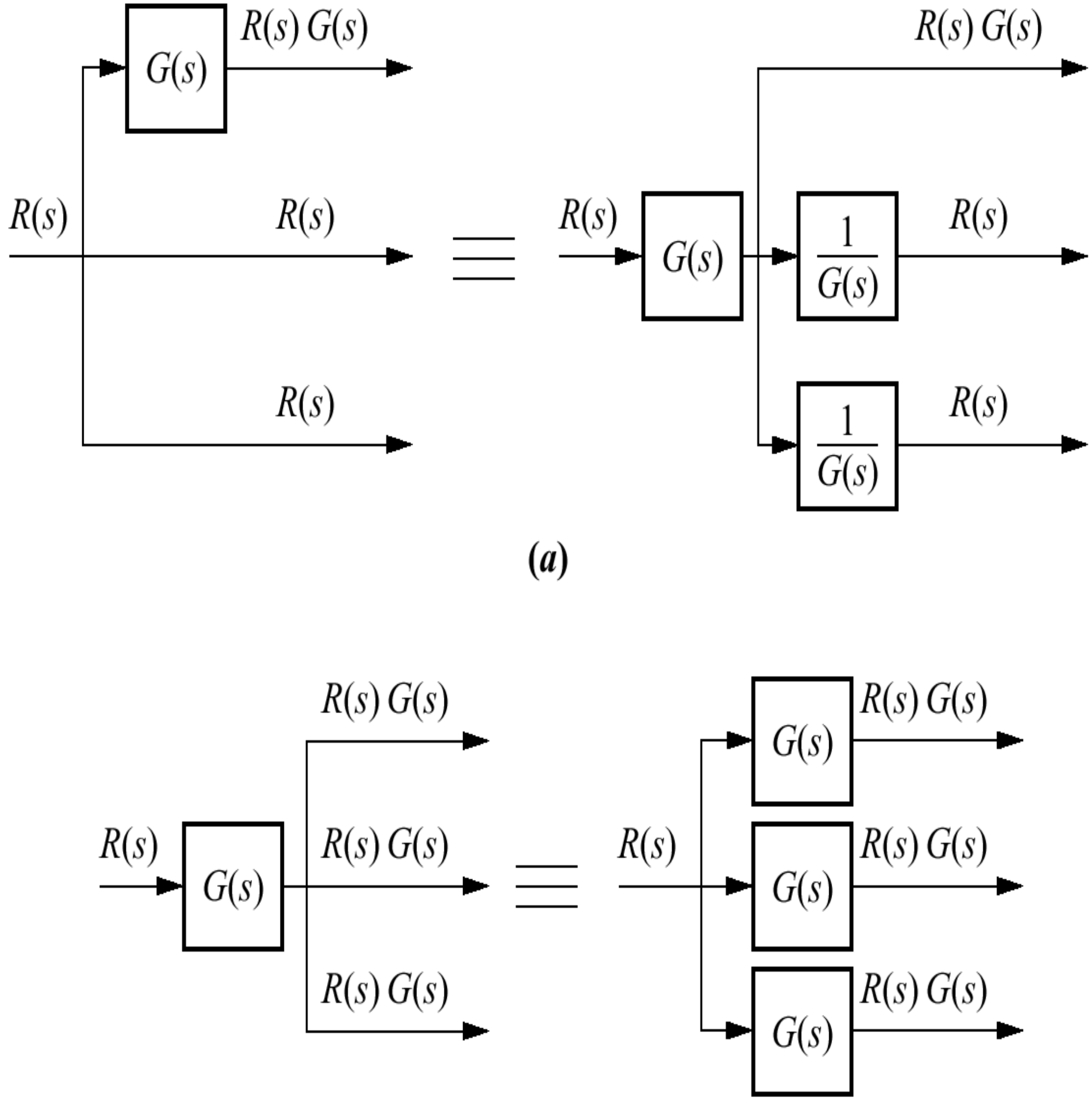


Figure 2.8

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



(a)

(b)

Figure 2.9

Block diagram for Example5.1

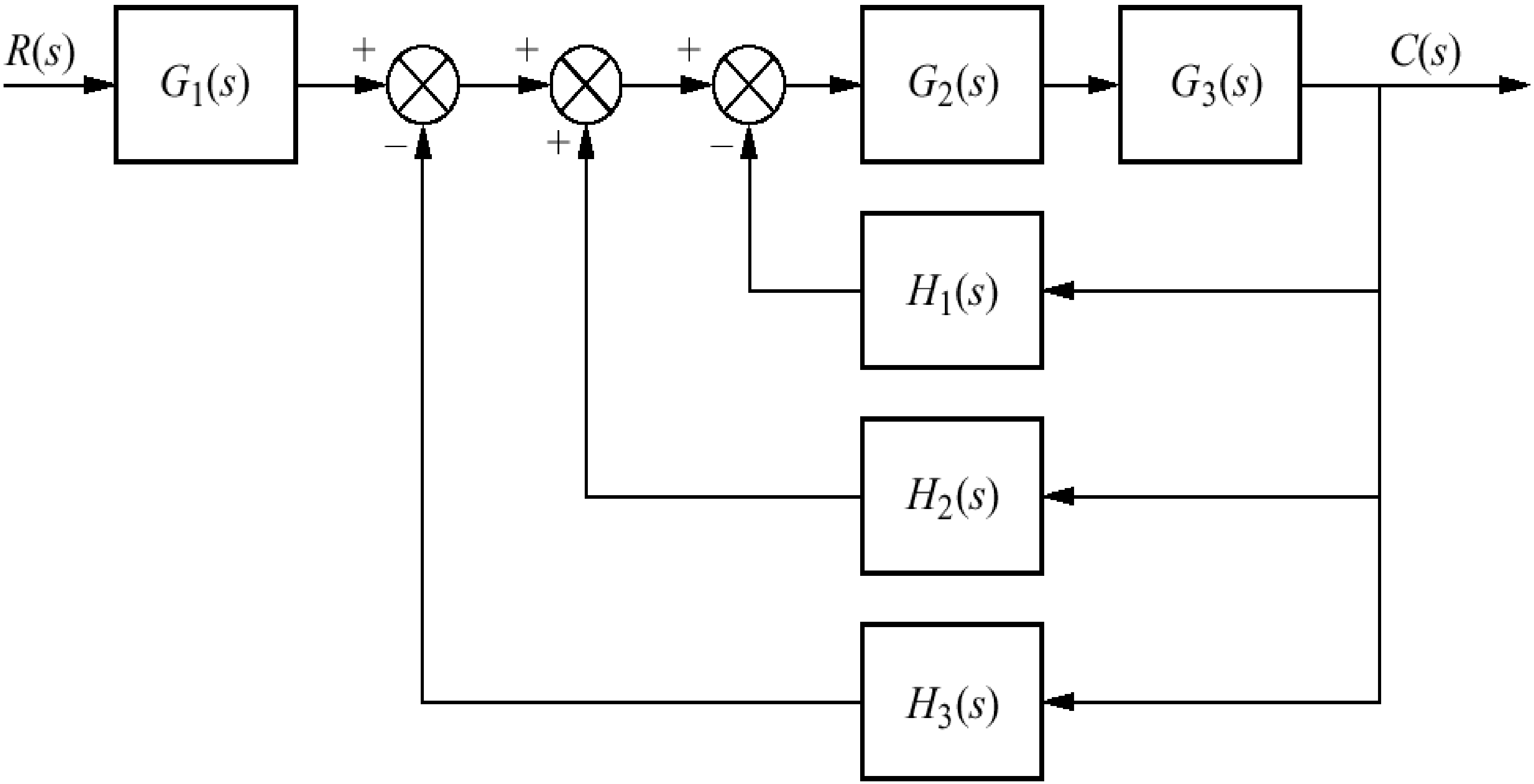
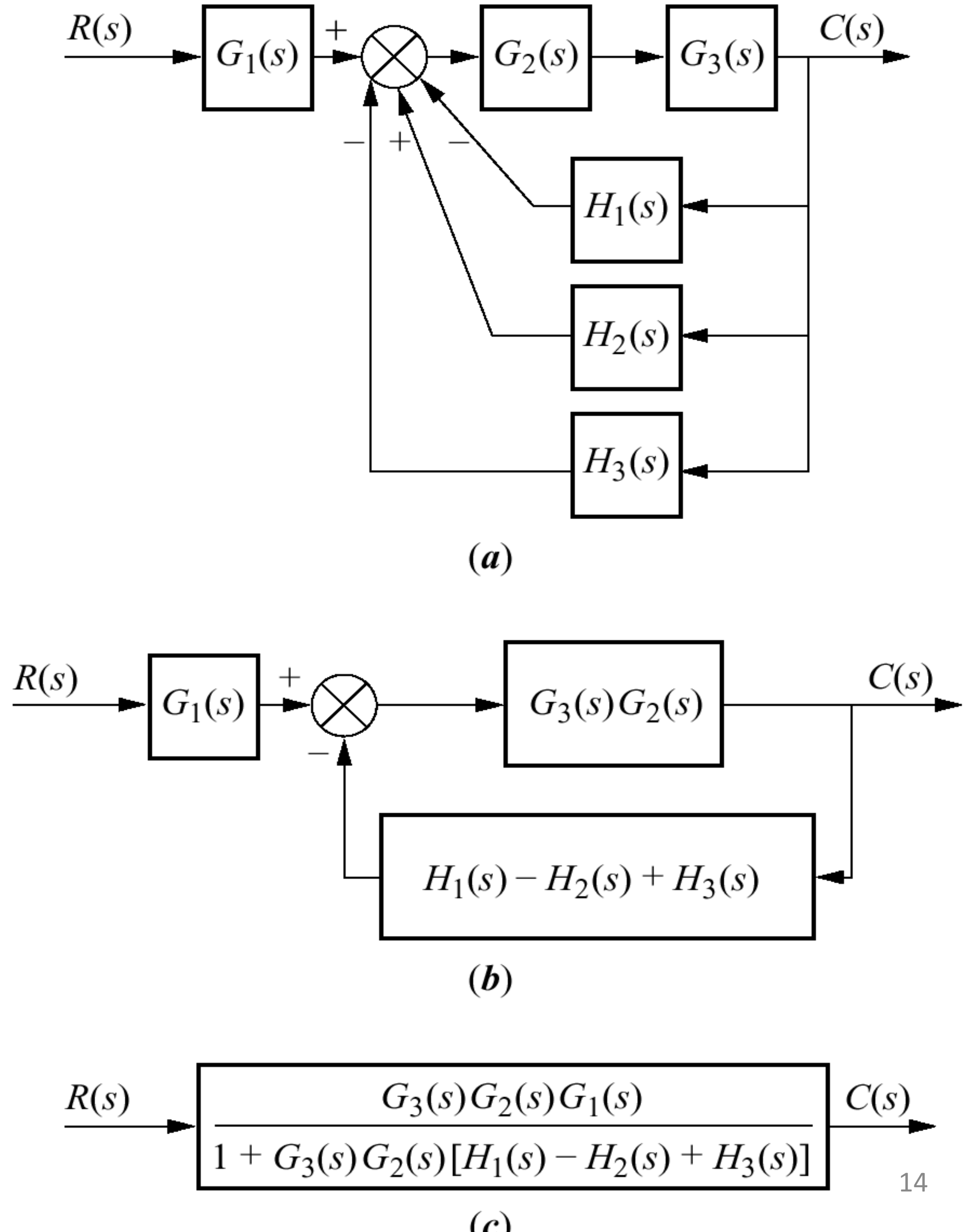


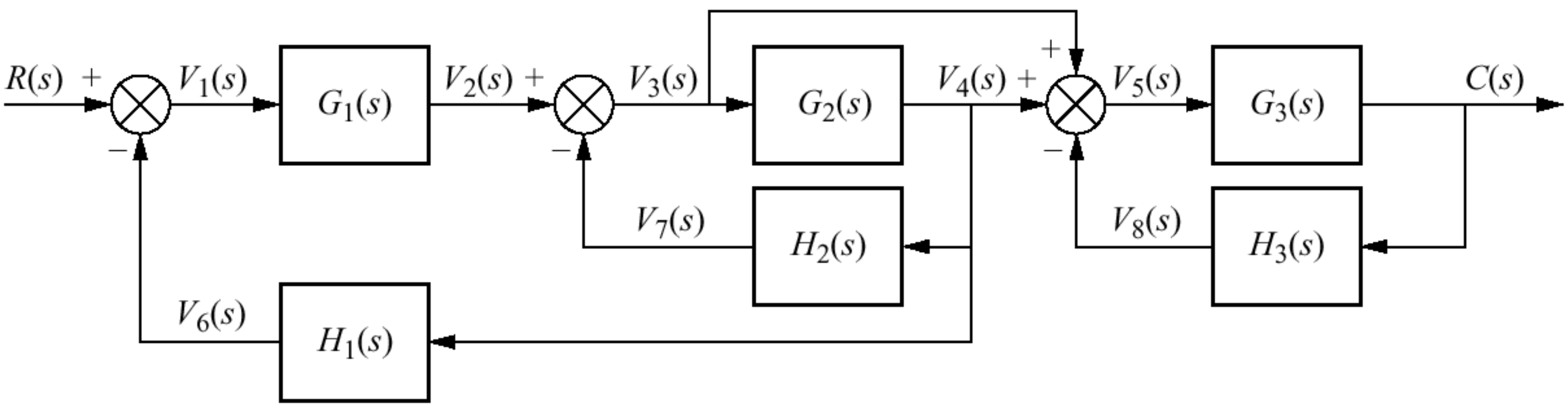
Figure 2.10

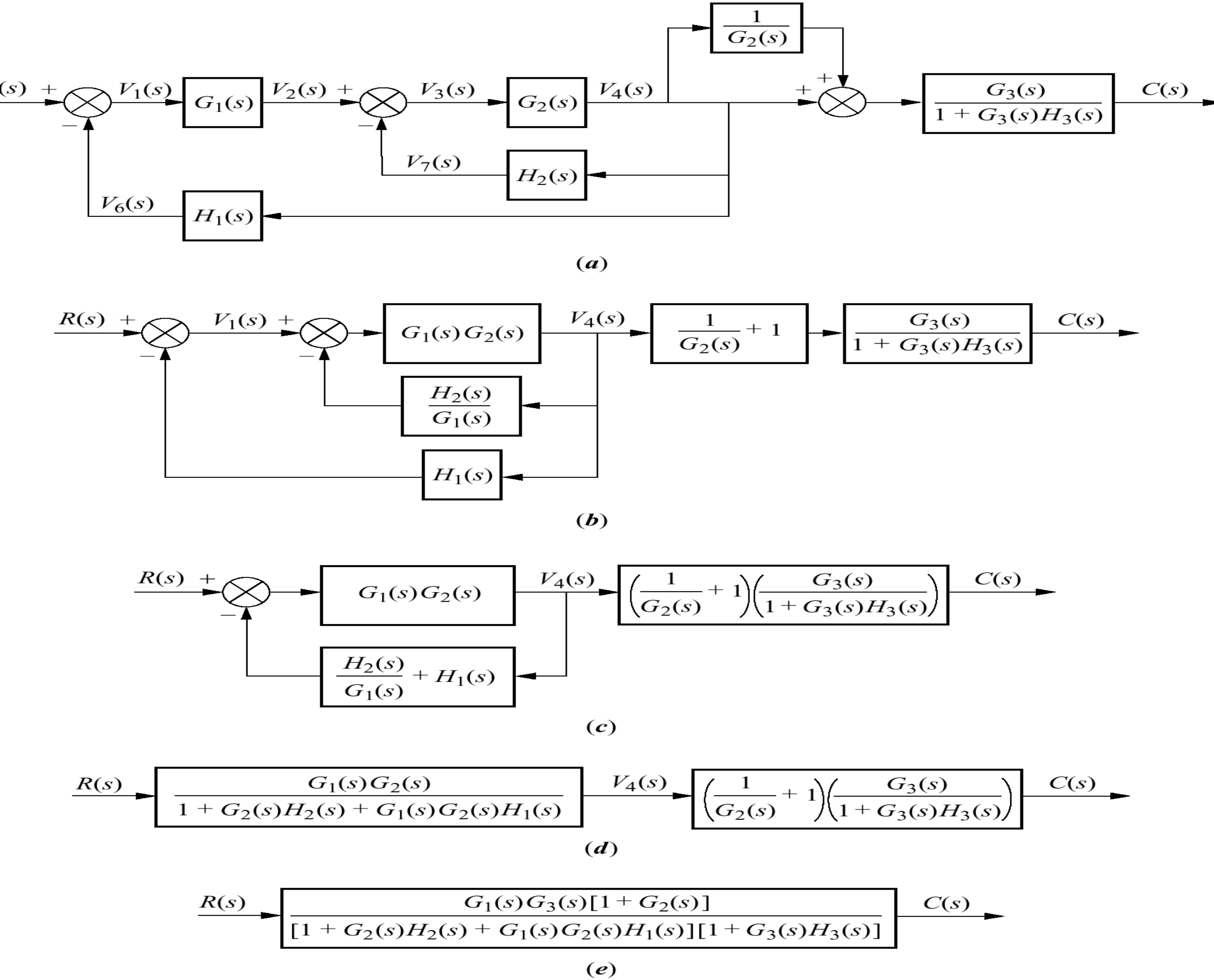
Steps in solving Example 5.1:
a. collapse summing junctions;
b. form equivalent cascaded system in the forward path and equivalent parallel system in the feedback path;
c. form equivalent feedback system and multiply by cascaded $G_1(s)$



(*a*) (*b*) (*c*)

Figure 2.11
Block diagram for Example 5.2




(s) + V1(s) G1(s) V2(s) + V3(s) G2(s) V4(s) 1/G2(s) + + G3(s)/(1 + G3(s)H3(s)) C(s)
− − V7(s) H2(s) V6(s) H1(s)
(a)
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)
(b)
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)
(c)
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)
(d)
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)
(e)