Control Systems

Subject Code: EC380

Lecture 3: Block Diagram Models

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Introduction

> A Block Diagram is a shorthand pictorial representation of the cause-and-effect relationship of a system.

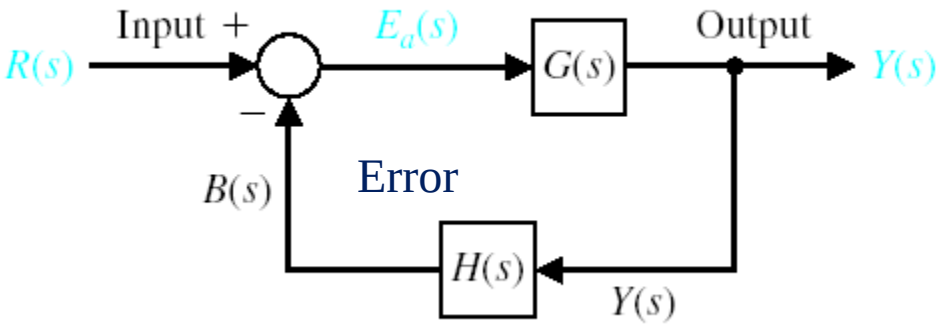
> Block diagram has four components:

Signals

System/ block

Summing junction

Pick-off/ Take-off point



> The simplest form of the block diagram is the single ***block, with one input and one output.***

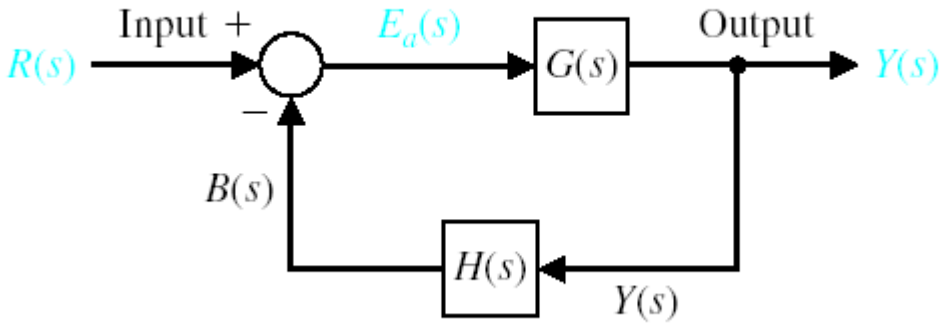
$$\frac{Y(s)}{R(s)} = \frac{G(s)}{1+G(s)H(s)}$$

Transfer Function of Negative Feedback Systems

Output, $Y(s)=G(s).E_a(s)$

Error, $E(s)=R(s)-B(s)$

Feedback, $B(s)=H(s)Y(s)$



$\gg Y(s)=G(s)R(s)-G(s)H(s)Y(s)$

$\gg (1+G(s)H(s))Y(s)=G(s)R(s)$

$\gg$ *Transfer Function,* $\frac{Y(s)}{R(s)}=\frac{G(s)}{1+G(s)H(s)}$

Different Definitions Related to Block Diagram

1. Open loop transfer function: $\frac{B(s)}{E(s)} = G(s)H(s)$
2. Feed Forward Transfer function: $\frac{C(s)}{E(s)} = G(s)$
3. Control ratio: $\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)H(s)}$
4. Feedback ratio: $\frac{B(s)}{R(s)} = \frac{G(s)H(s)}{1+G(s)H(s)}$
5. Error ratio: $\frac{E(s)}{R(s)} = \frac{1}{1+G(s)H(s)}$
6. Closed loop transfer function: $\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)H(s)}$
7. Characteristic equation:

$$1+G(s)H(s)=0$$

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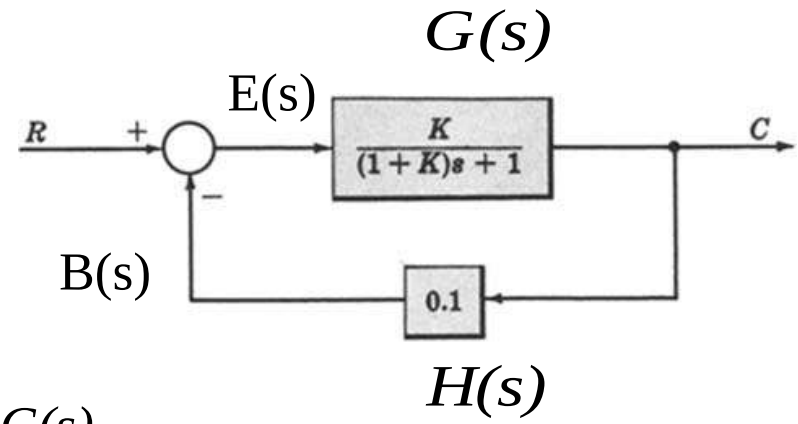


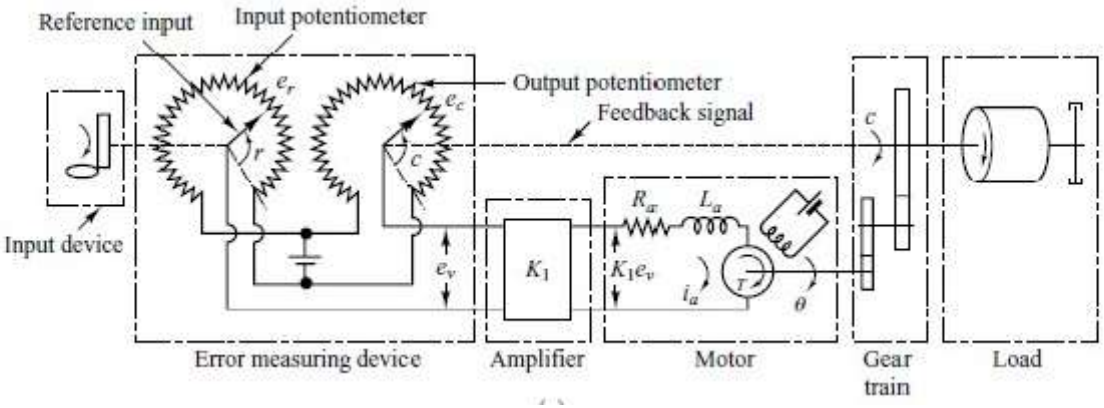
R - Input Signal

C- Output Signal

E- Error Signal

B- Feedback Signal

SERVOMOTOR



Error, $e = r - c$

$e_v = e_r - e_c$

$e_v = k_o \times e$

Torque, $T = K_2\, i_a$

Back emf, $e_b = k_3 \dfrac{d\theta}{dt}$

Armature circuit, $L_a \dfrac{di_a}{dt} + R_a i_a + e_b = K_1 e_v$

Torque equilibrium, $J_o \dfrac{d^2\theta}{dt^2} + b_0 \dfrac{d\theta}{dt} = T$

K. Ogata, *Modern Control Engineering*, Prentice Hall India, 2010.

Block Diagram of Servomotor

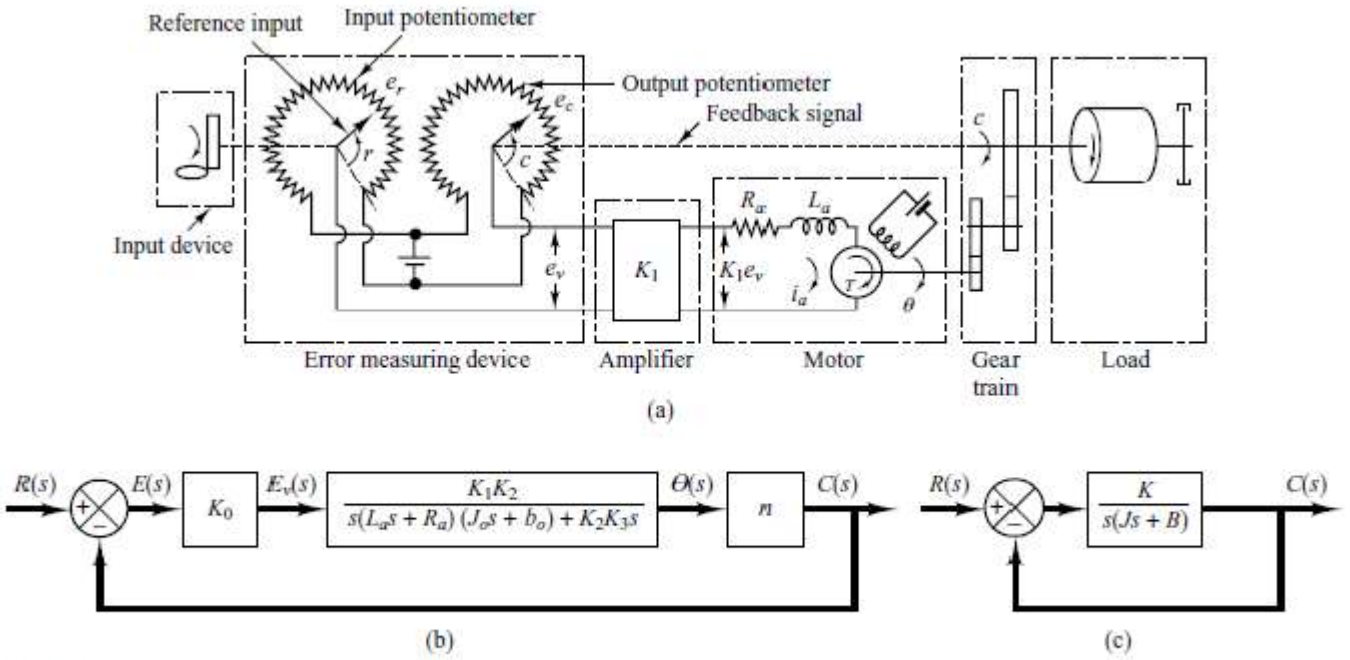
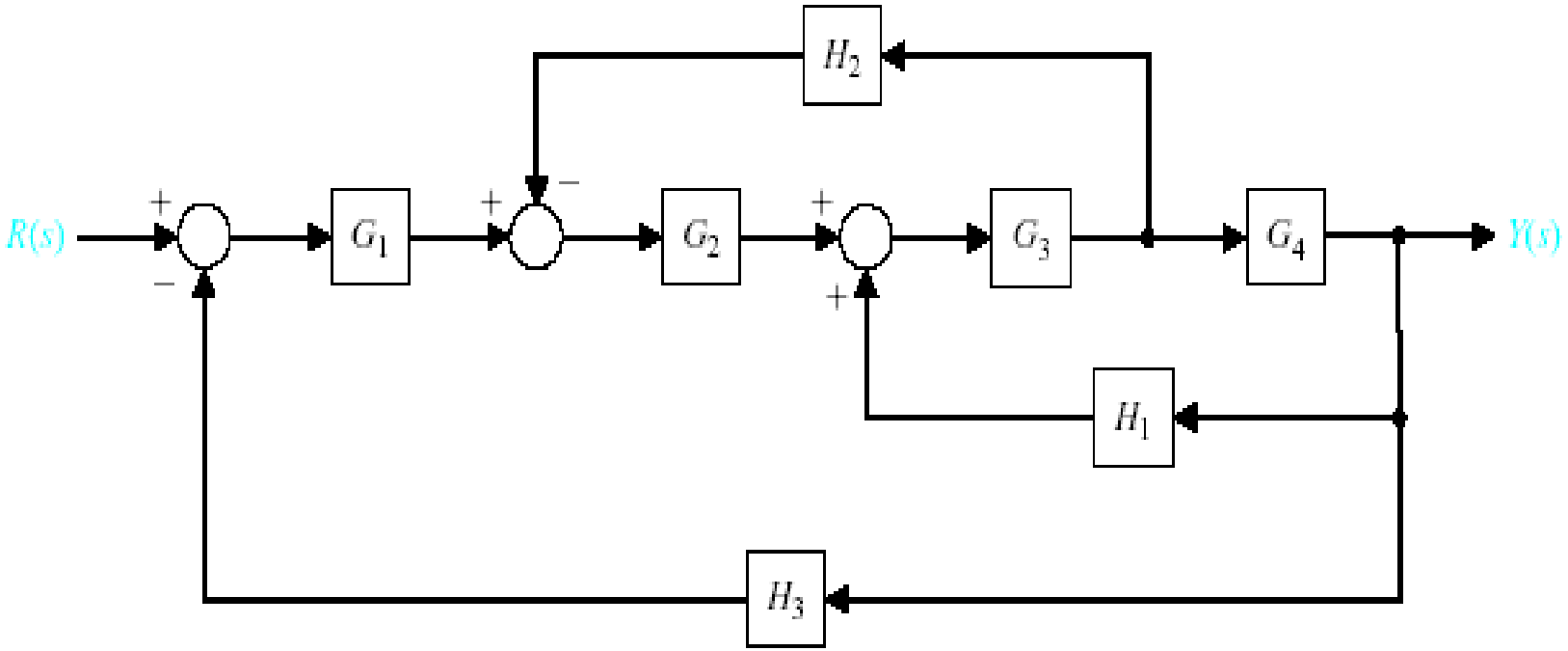


Figure 3–29
(a) Schematic diagram of servo system; (b) block diagram for the system; (c) simplified block diagram.

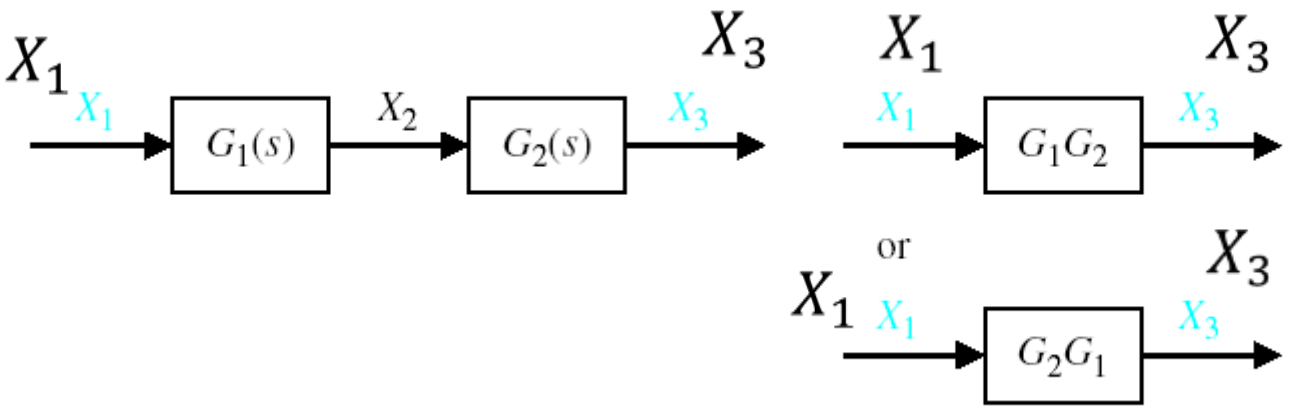
K. Ogata, *Modern Control Engineering*, Prentice Hall India, 2010.

What is the transfer function, Y(s)/R(s)= ?

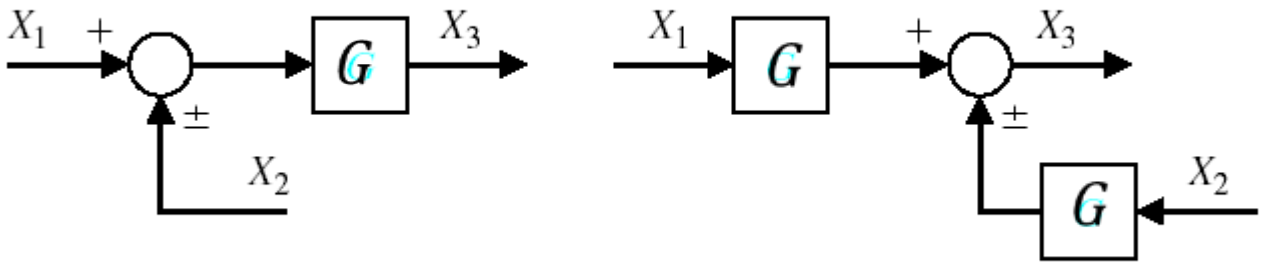


Original Diagram Equivalent Diagram

1. Combining blocks in Cascade:

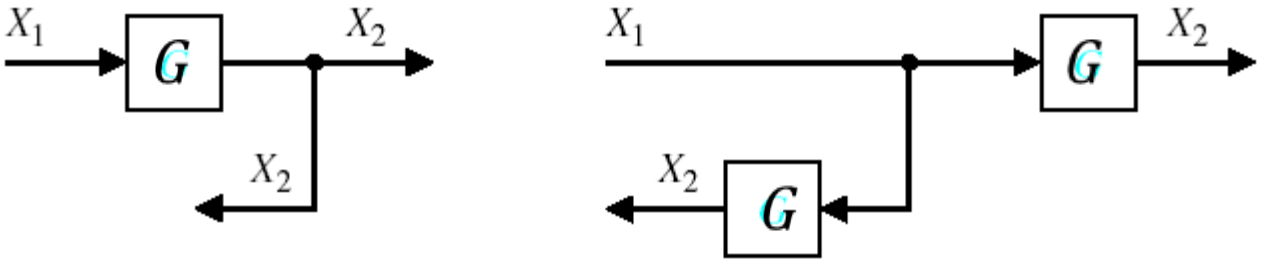


2. Moving a summing point behind a block:

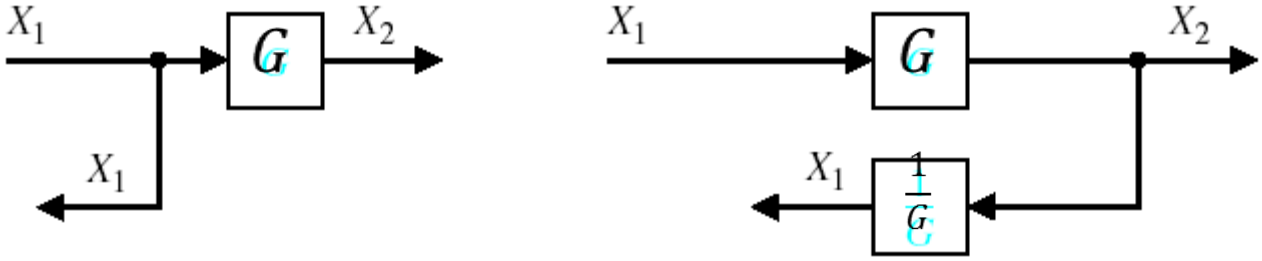


Original Diagram Equivalent Diagram

3. Moving a pickoff point ahead of a block:

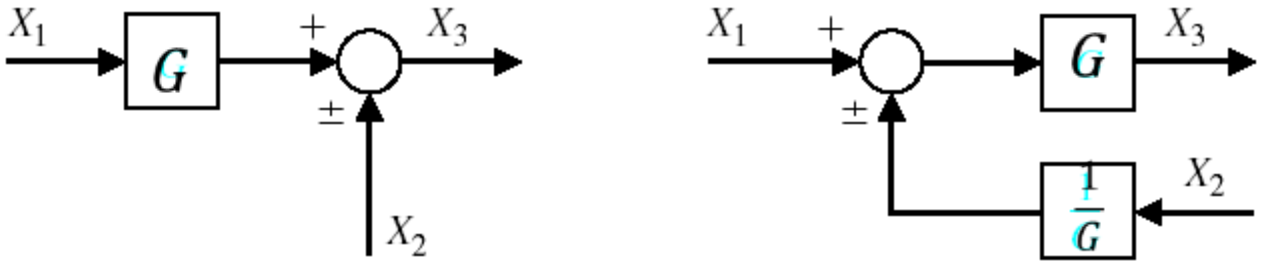


4. Moving a pickoff point behind a block:

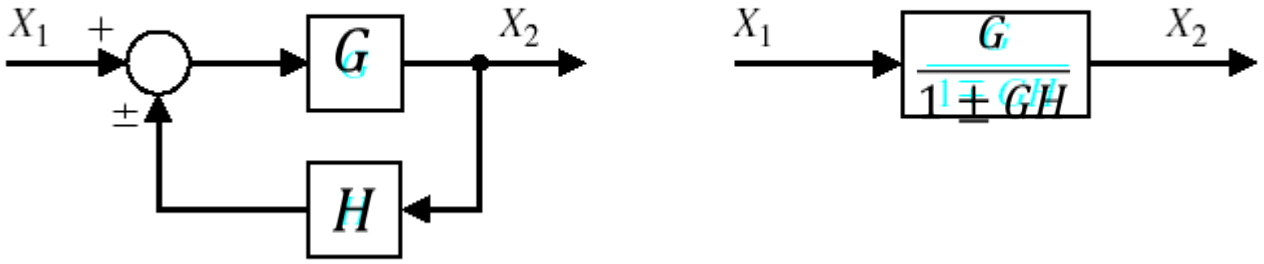


Original Diagram Equivalent Diagram

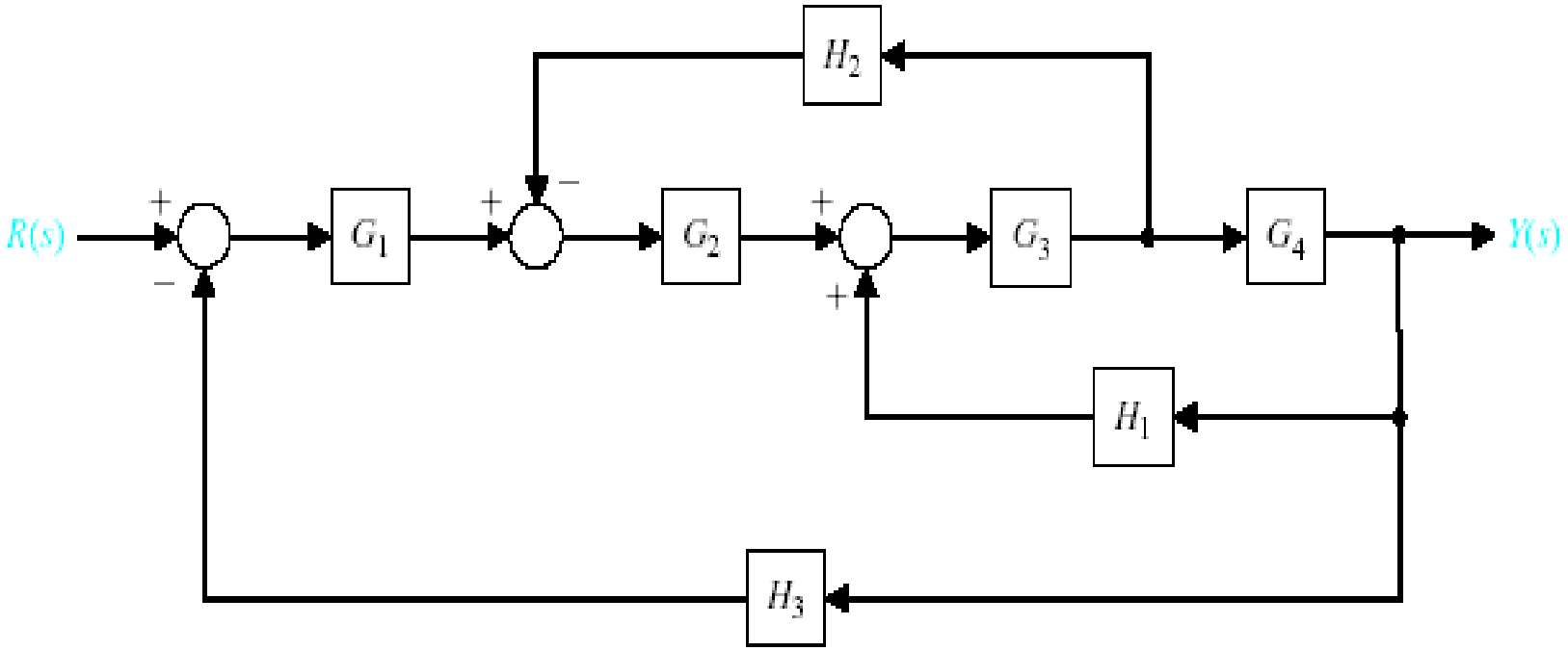
5. Moving a summing point ahead of a block:



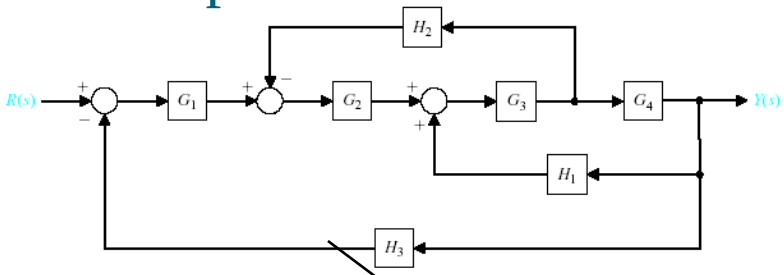
6. Eliminating a feedback loop:

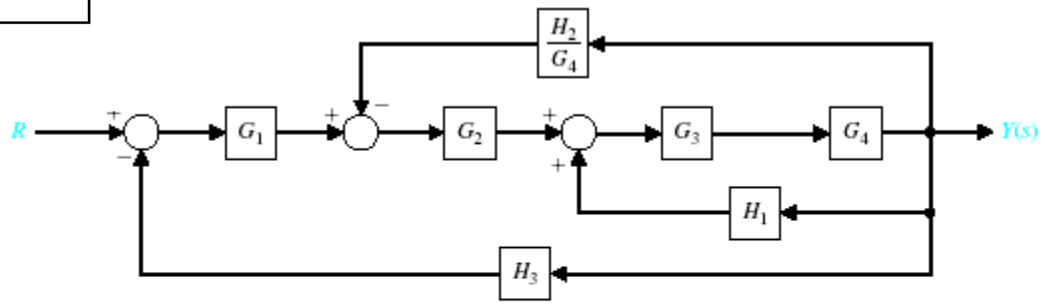


Example-1

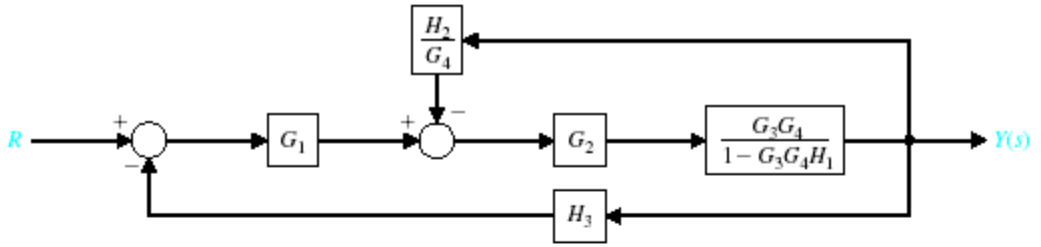


Example-1

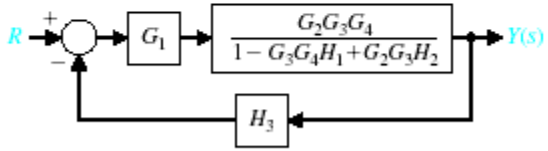




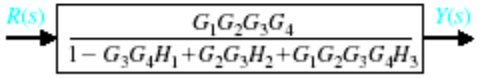
(a)



(b)



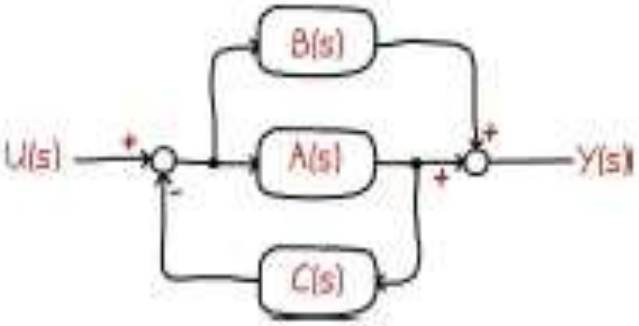
(c)



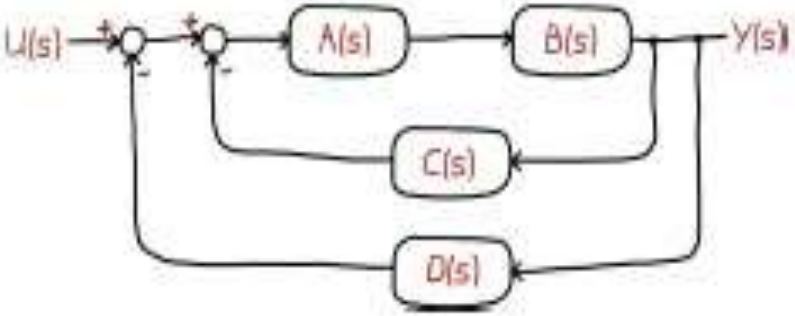
(d)

2. Simplify these block diagrams. Find the transfer function for each system.

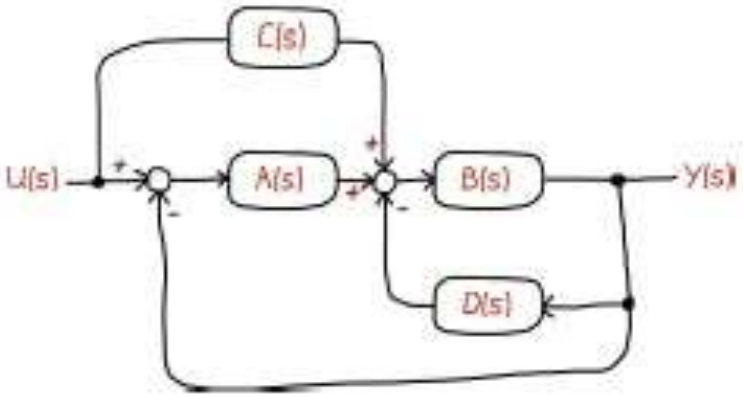
a)



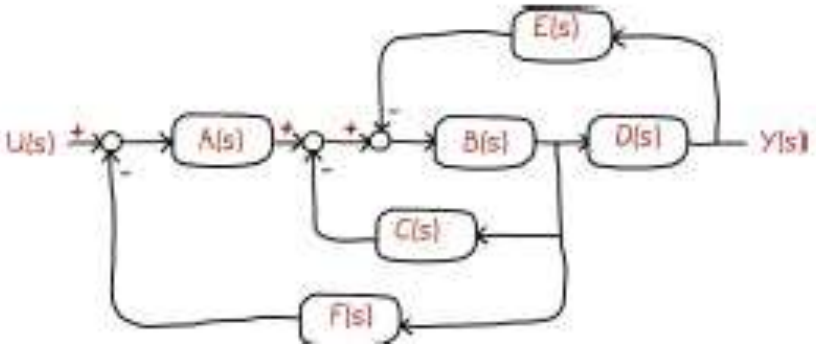
b)



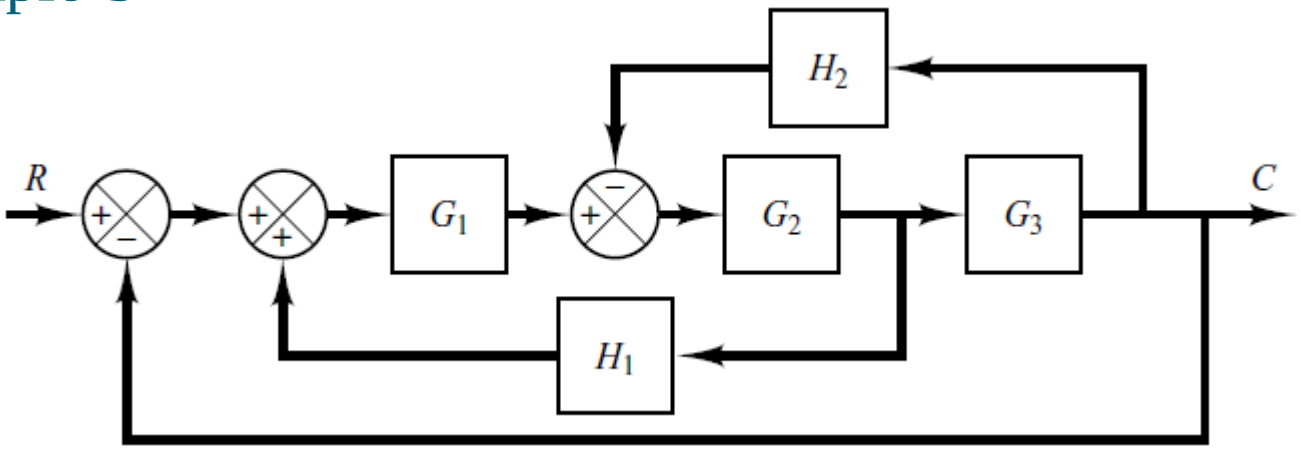
c)



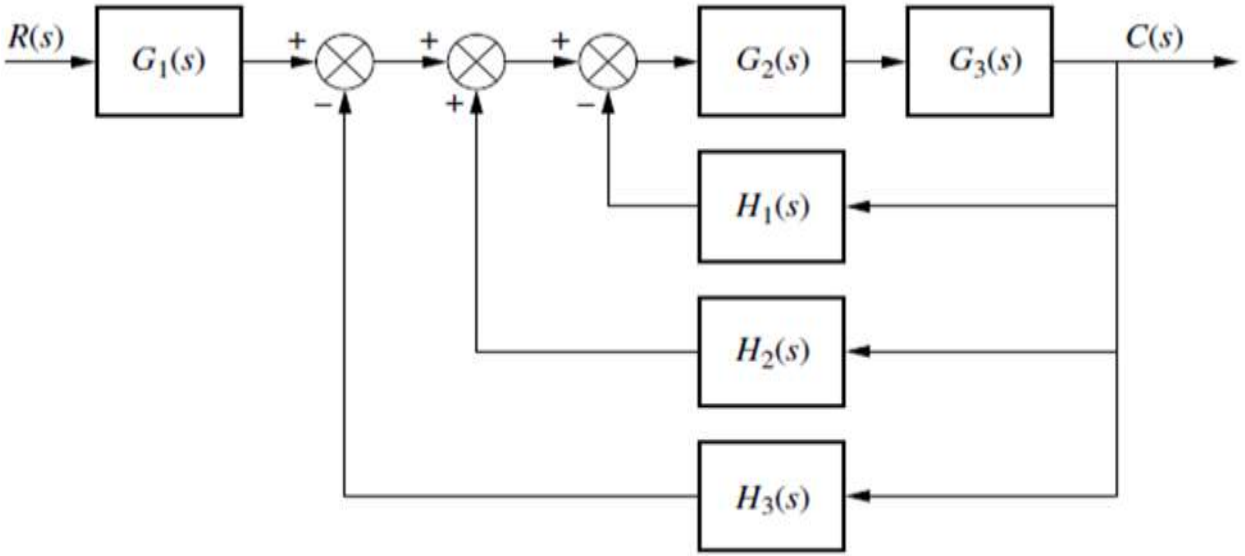
d)



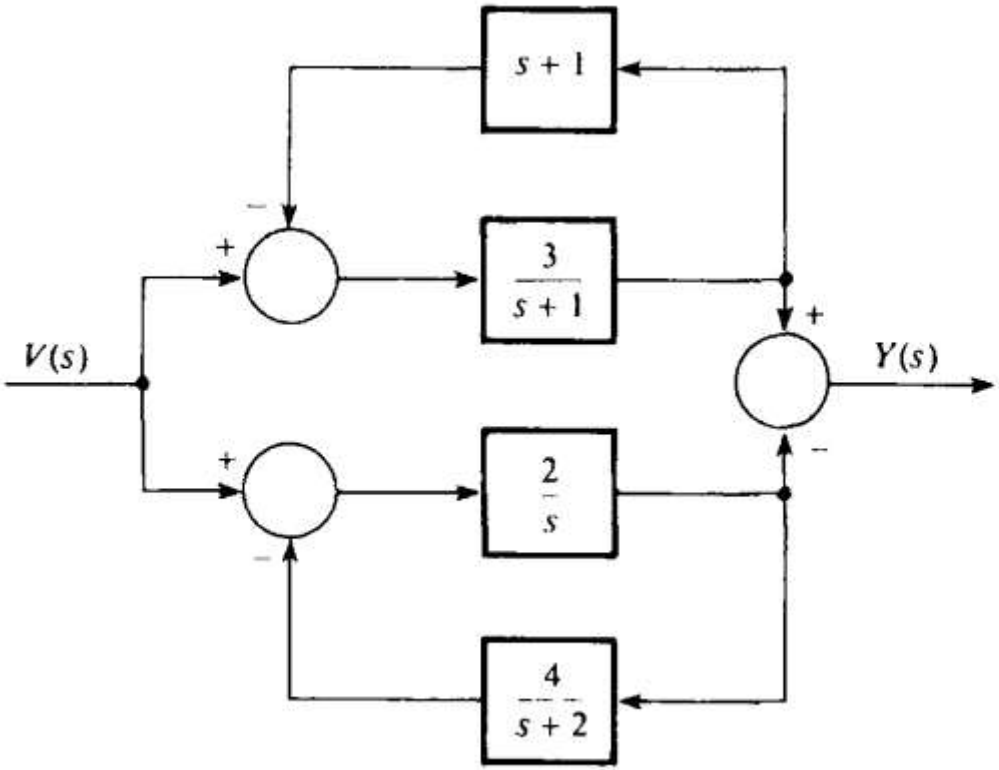
Example-3



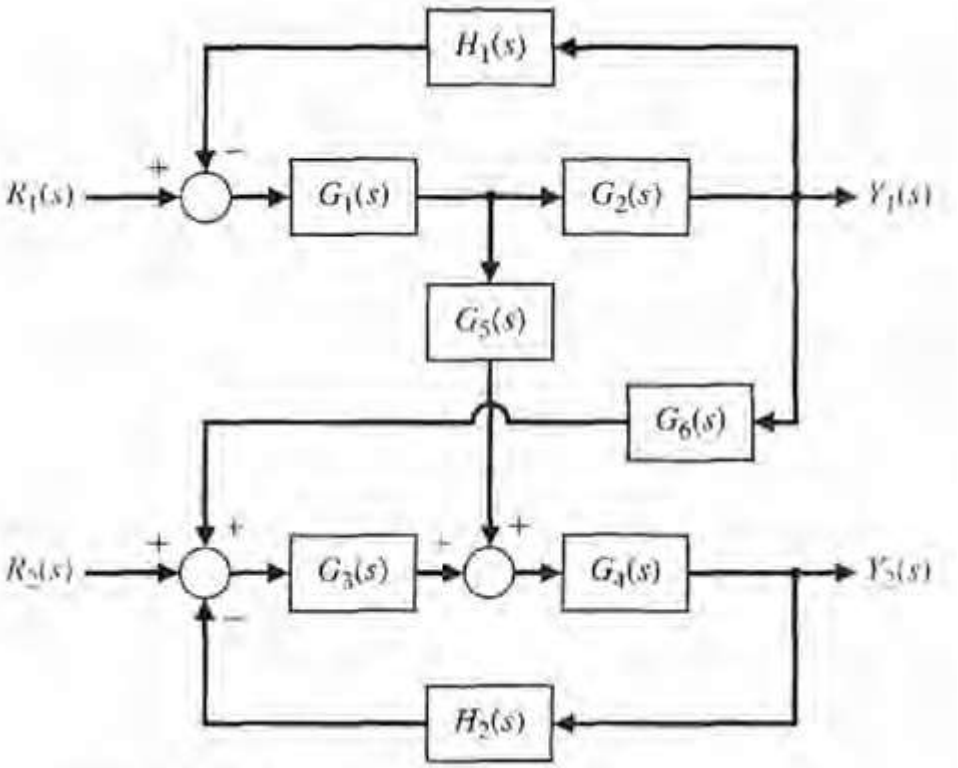
Example-4



Example-5



Example-6



Determine the transfer functions:

i) $\frac{Y_1(s)}{R_1(s)}$ when $R_2(s)=0$ and ii) $\frac{Y_2(s)}{R_2(s)}$ when $R_1(s)=0$,

Home Work

Reduce this block diagram to create a system with unity feedback.