Block Diagram Representation

- *I/O Form of Dynamical Systems*
- *Block Diagram Representation*
- *Algebraic Manipulations of Block Diagrams*

I/O Form and Block Diagrams

Input – Output Representations

Mathematical models are **commonly written** in forms that describe **variation** of output with respect to input, as below.

$$y(t) = gu(t); \quad g = {y(t)}/{u(t)}$$

Here, **u(t)** is input, **y(t)** is output and '**g**' is the **relation** between 'y' and 'u' that **'transforms' 'u'** into **'y'.** E.g. spring-mass-damper model **can be rewritten**, as follows.

$$m\frac{d^2y}{dt^2} + b\frac{dy}{dt} + ky = b\frac{du}{dt} + ku$$

$$y(t) = gu(t), \quad g = \frac{b\left({d}/{dt}\right) + k}{m\left({d^2}/{dt^2}\right) + b\left({d}/{dt}\right) + k}$$

Block Diagram as System Form

Block diagrams are an extension of the **I/O form** and are pictorial **representation** of the model of the **system.**

Typical **block** is the basic unit **represented** as follows.

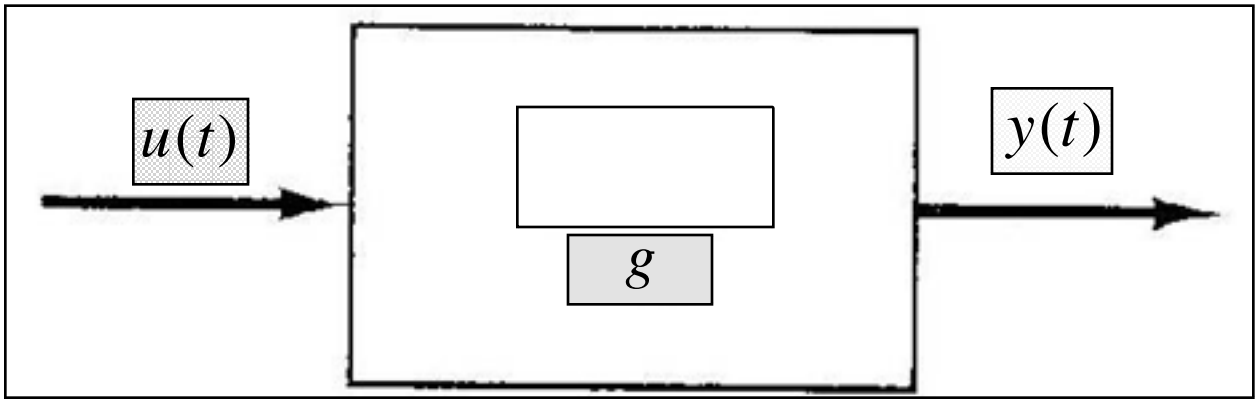
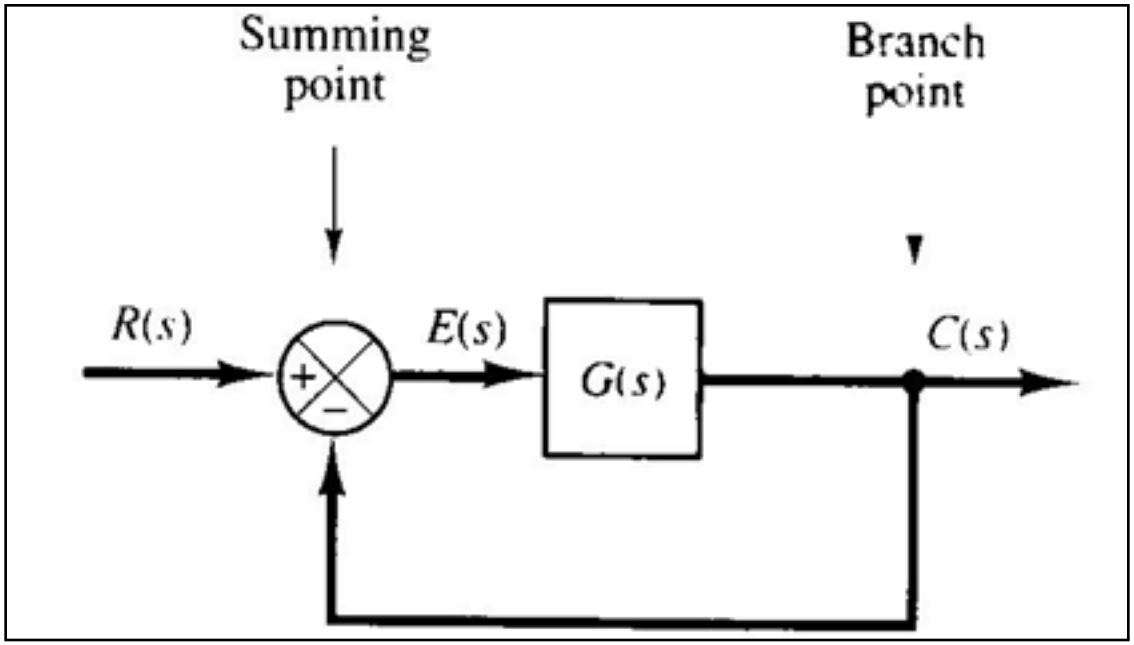


Diagram contains algebraic **operations** e.g. multiplication / division, addition/ subtraction, **consistent** with the model **description.**

Block Diagram as Dynamical Tool

Block diagrams are also tools for **analysis and design** as these can be **manipulated** like algebraic entities, using the applicable **relations**. A typical **diagram** is shown below.



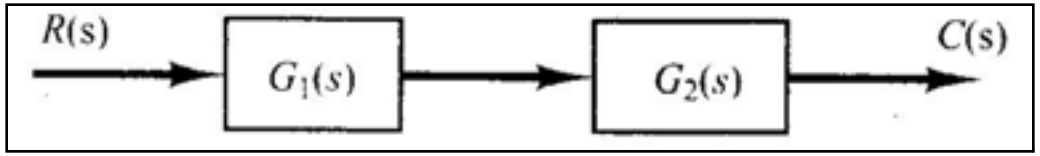
Summing point defines the algebraic **equation** in terms of inputs & output.

Branch point provides **signal to other** blocks or summing points.

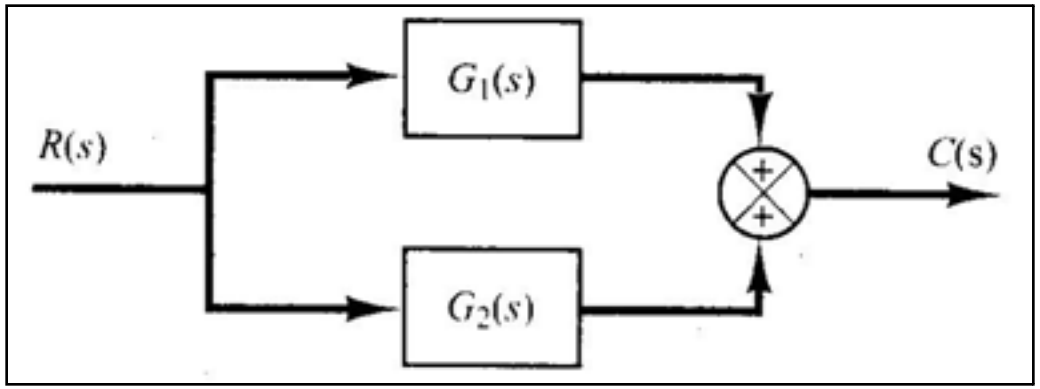
Block represents the **process.**

Block Diagram Algebra Concept

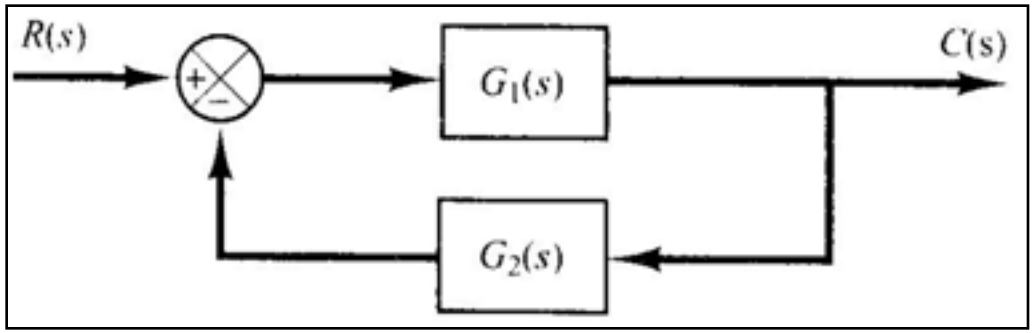
Block diagram algebra is a **discipline** that helps us to **manipulate** diagrams, as algebraic entities.



$$\frac{C(s)}{R(s)} = G_1(s) \cdot G_2(s)$$



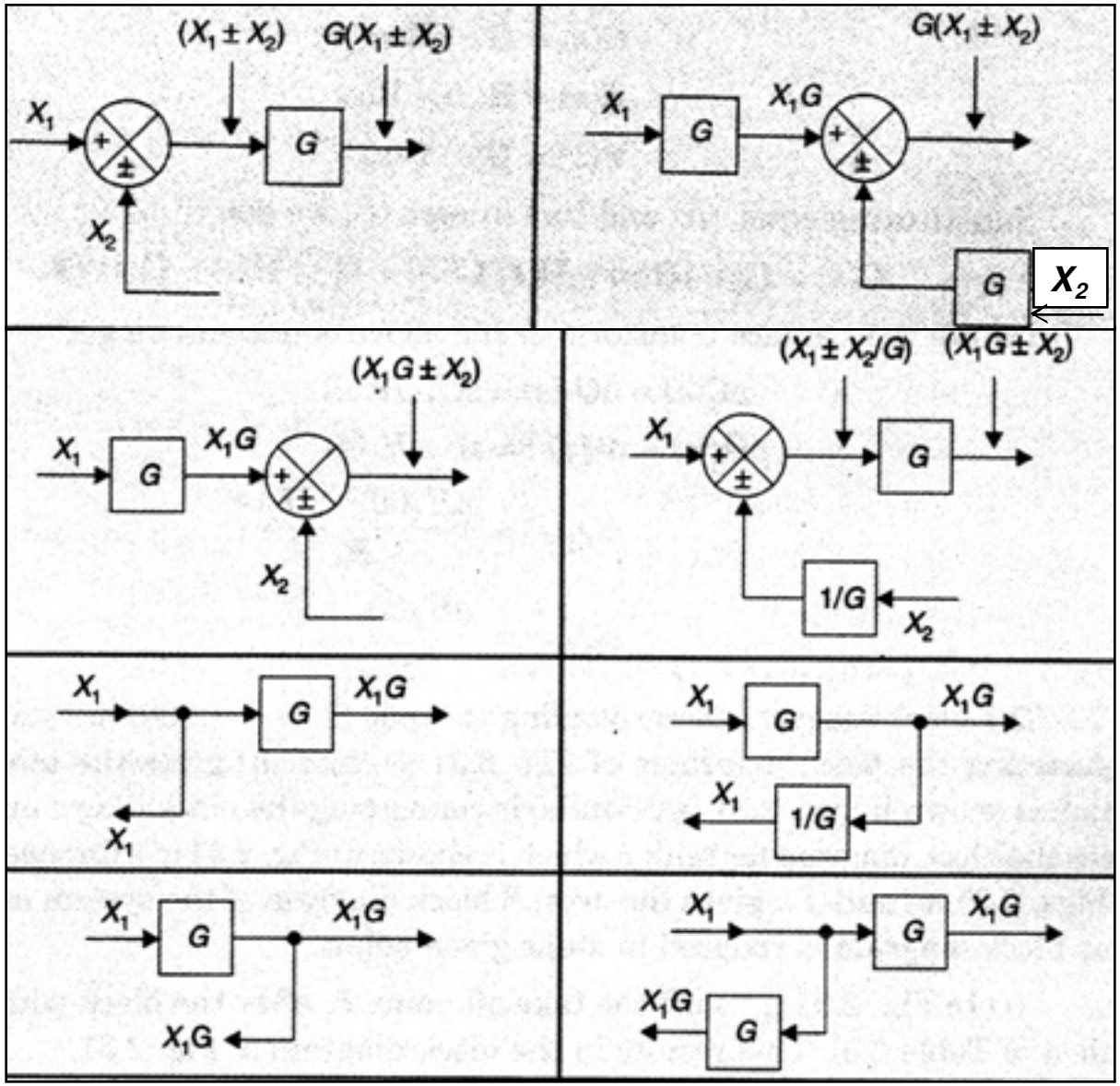
$$\frac{C(s)}{R(s)} = G_1(s) + G_2(s)$$



$$\frac{C(s)}{R(s)} = \frac{G_1(s)}{1 + G_1(s) \cdot G_2(s)}$$

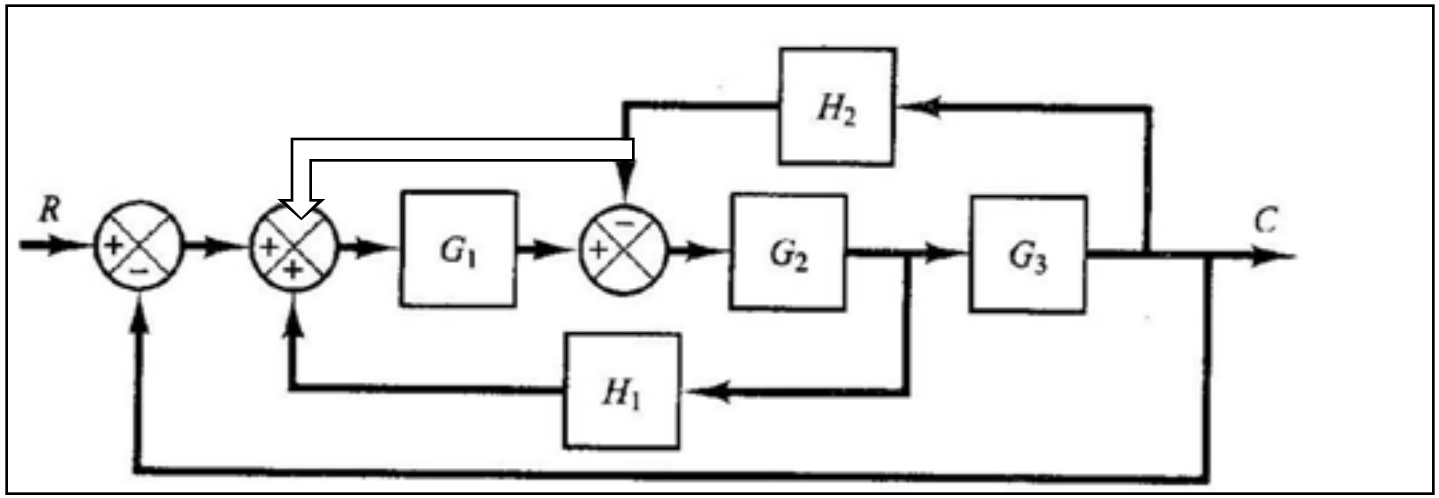
Rules for Block Diagram Algebra

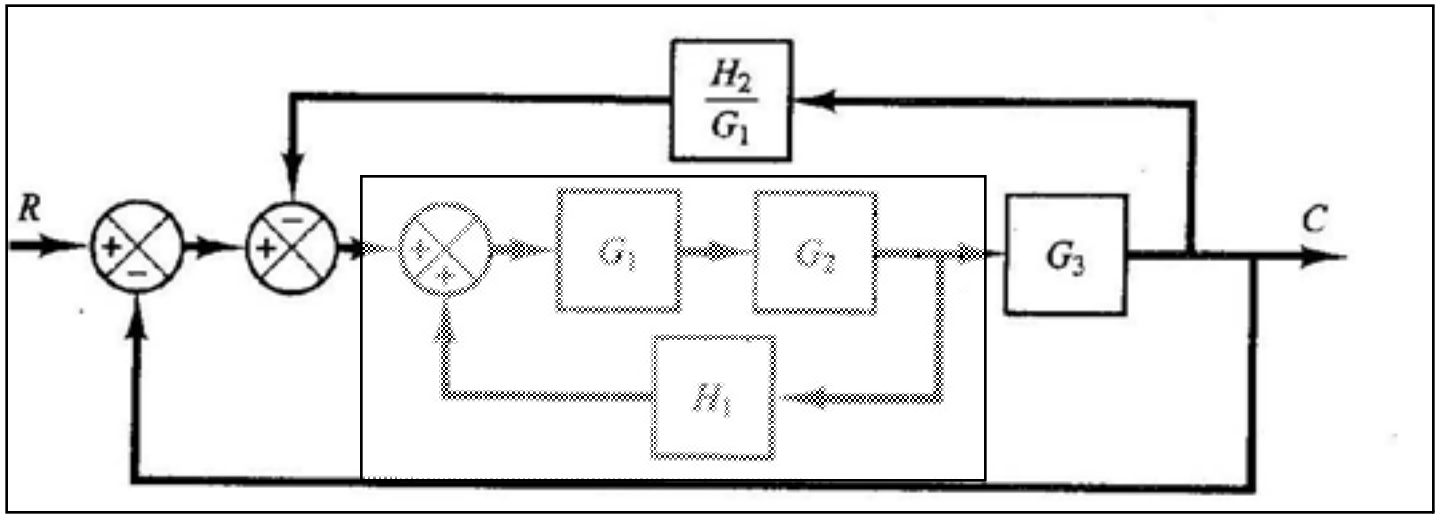
Given along side are **some** of the **rules** that we can use to **manipulate / simplify** system **description.**



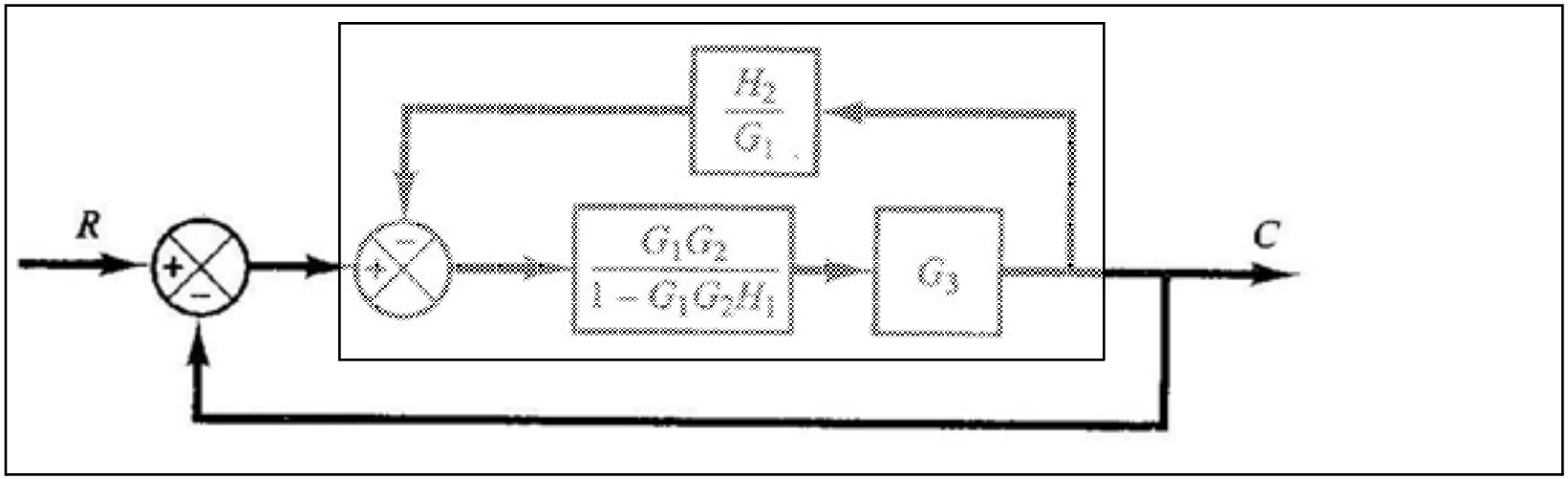
Block Diagram Algebra Example

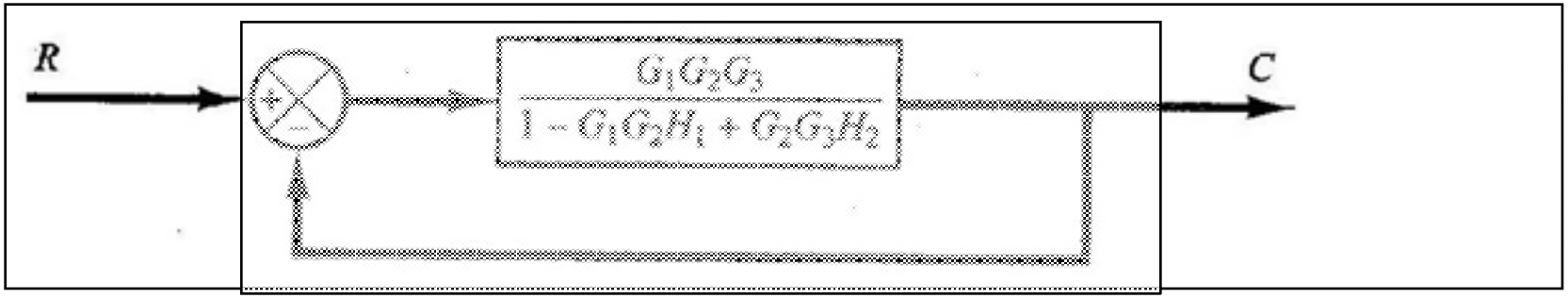
Consider the following **block diagram.**

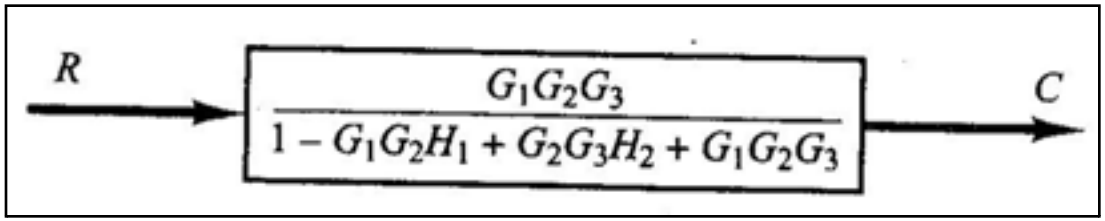




Block Diagram Algebra Example







Summary

Block diagrams are the most common and **convenient representations** for dynamical systems, which can be manipulated like **algebraic entities.**