

# **7. Zadanie z LCRP – teoretická časť**

**J. Oravec**

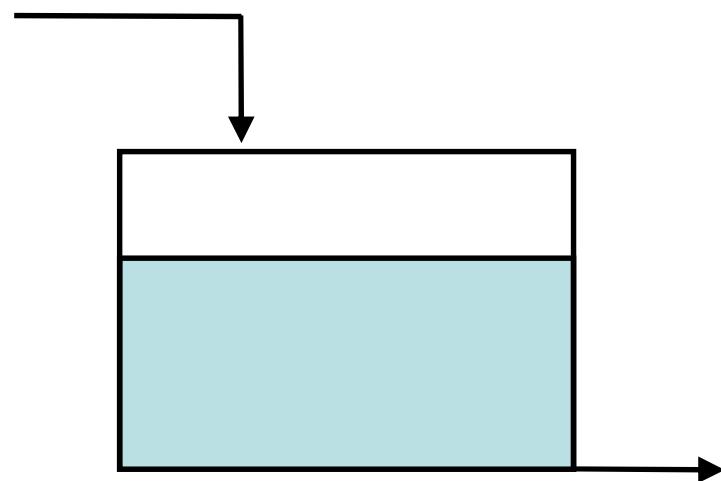
## **7. Zadanie z LCRP – teoretická časť**

- **URO**
- **prenos URO**
- **CHR URO**
- **zákon riadenia**
- **Routhovo-Schurovo kritérium stability**

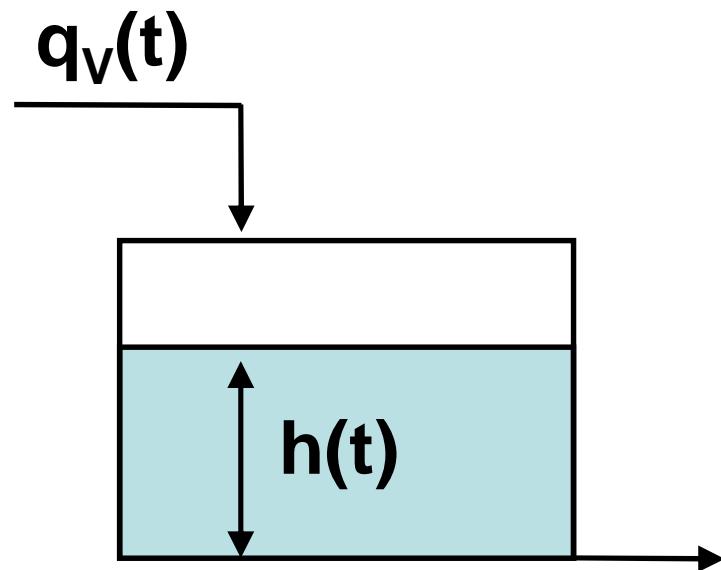
## 7. Zadanie z LCRP – teoretická časť

- **URO**
- prenos URO
- CHR URO
- zákon riadenia
- Routhovo-Schurovo kritérium stability

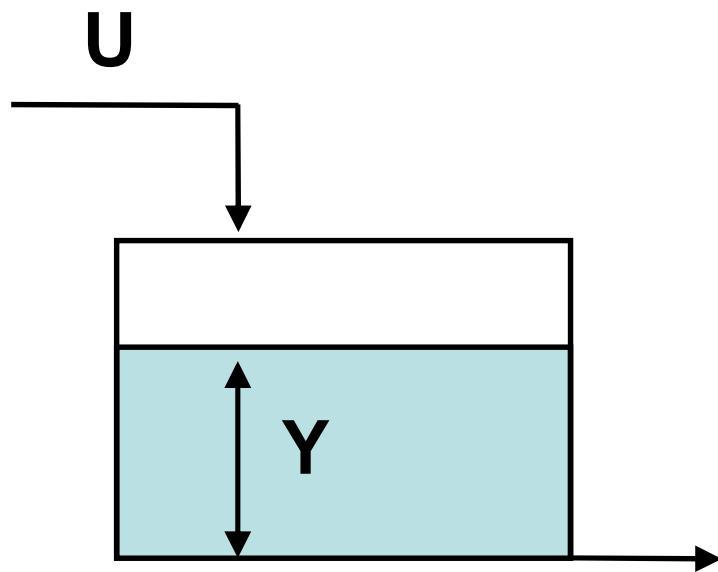
# URO



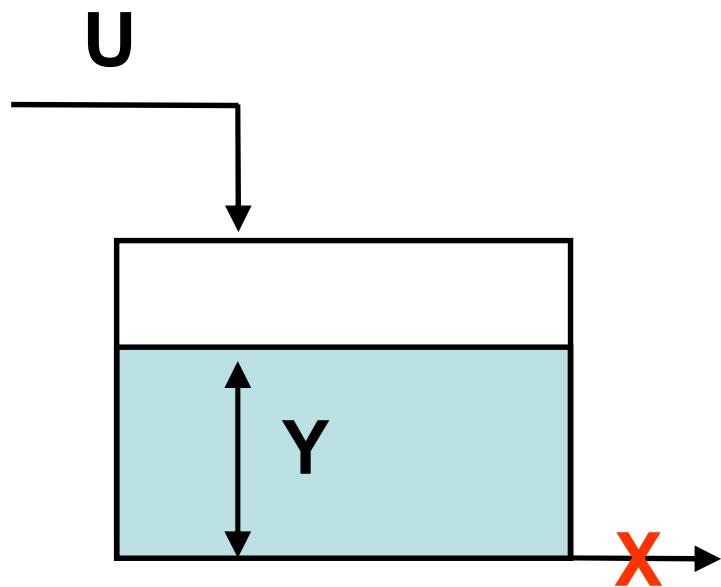
# URO



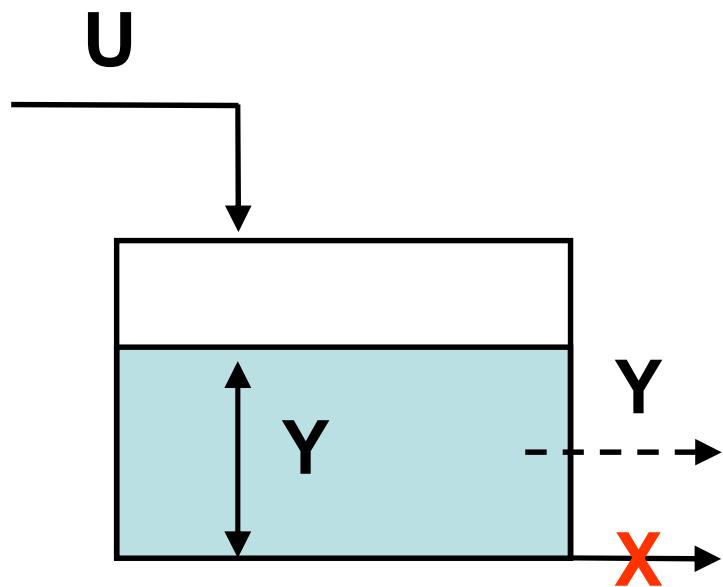
# URO



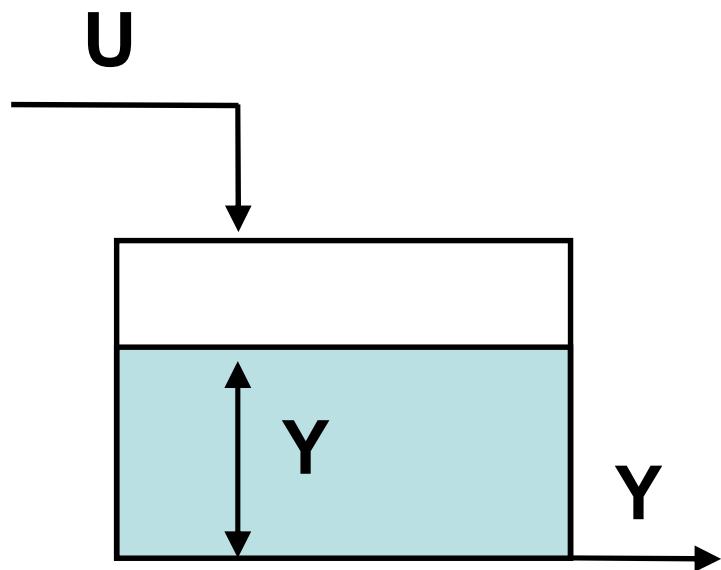
# URO



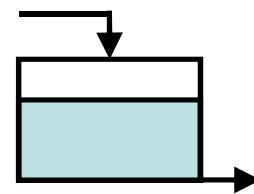
# URO



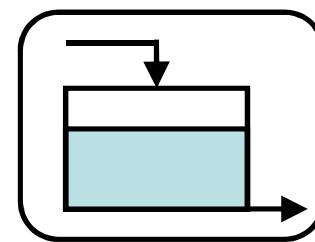
# URO



# URO



# URO



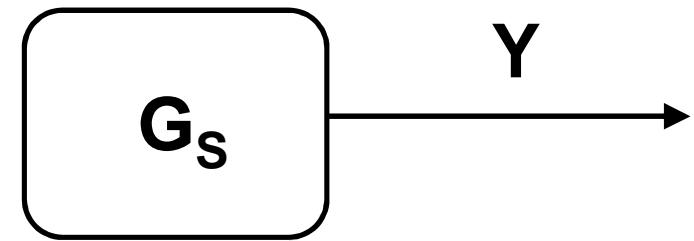
# URO

proces

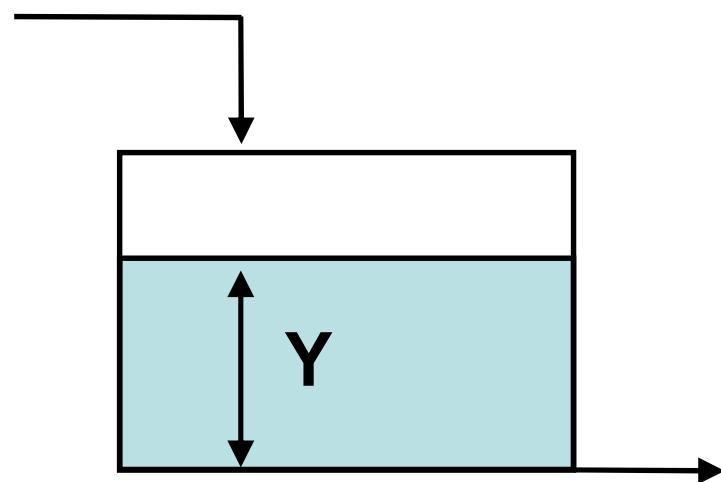
# URO

**G<sub>S</sub>**

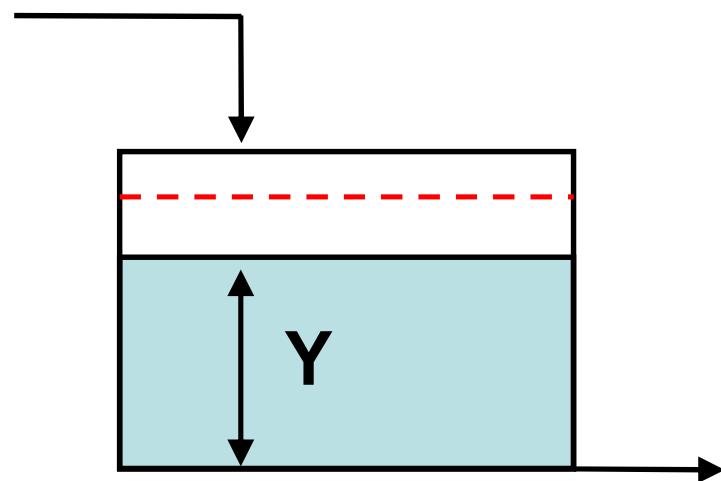
# URO



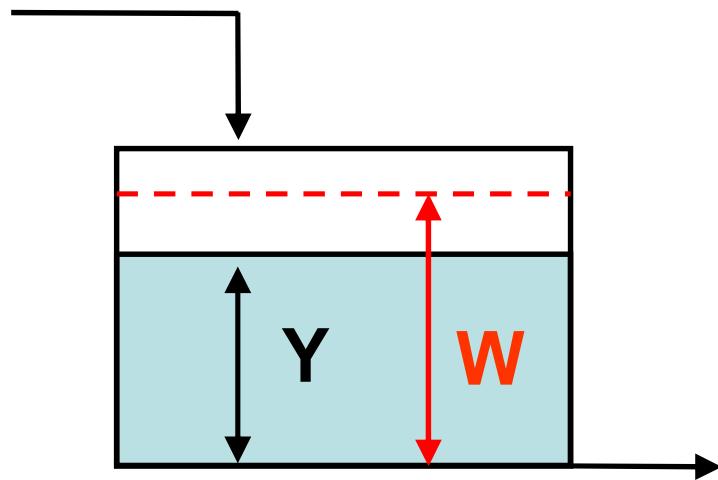
# URO



# URO

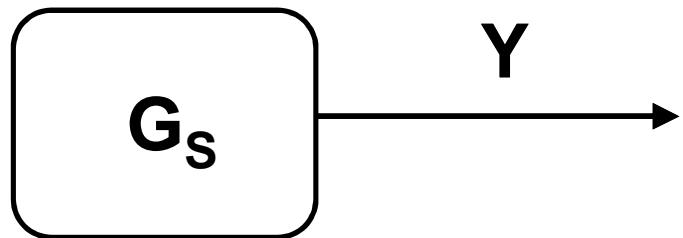


# URO

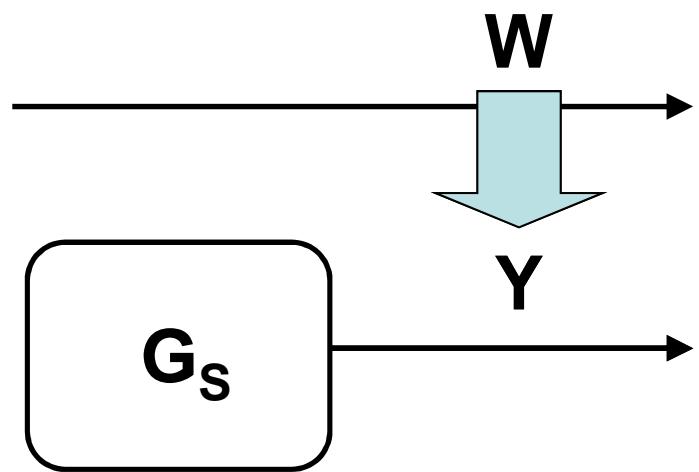


# URO

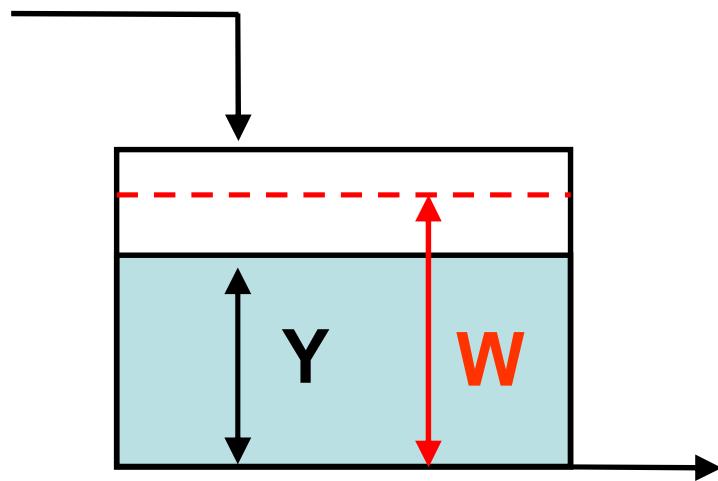
W



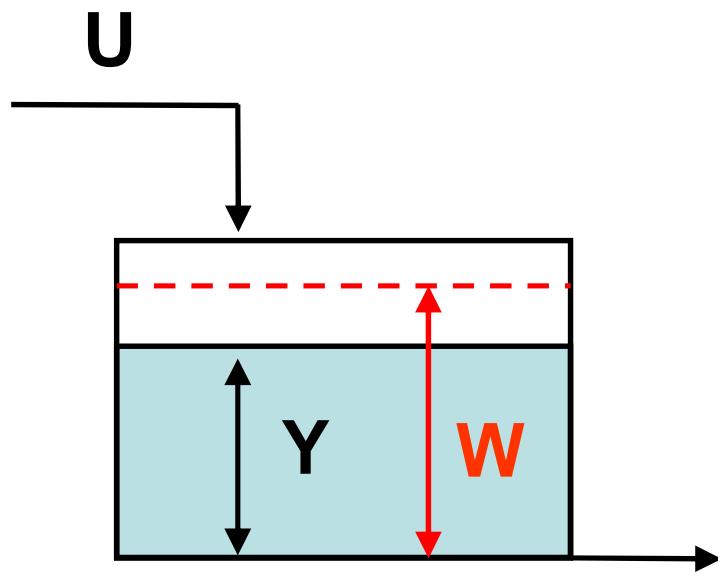
# URO



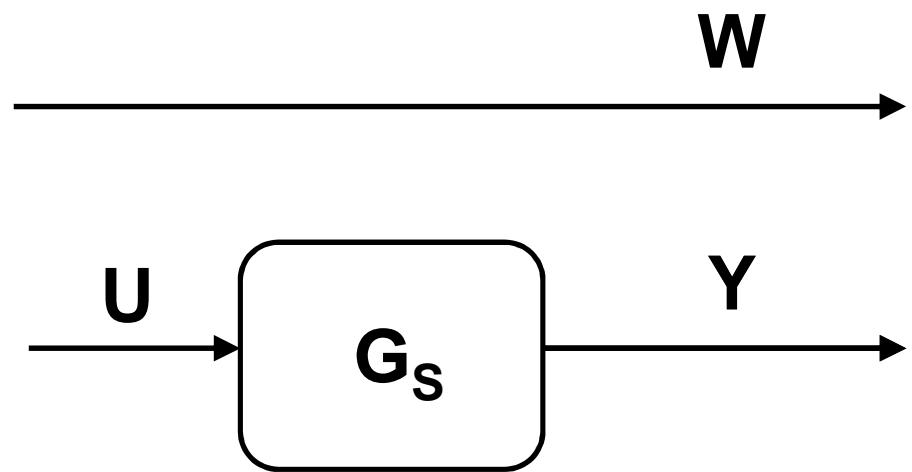
# URO



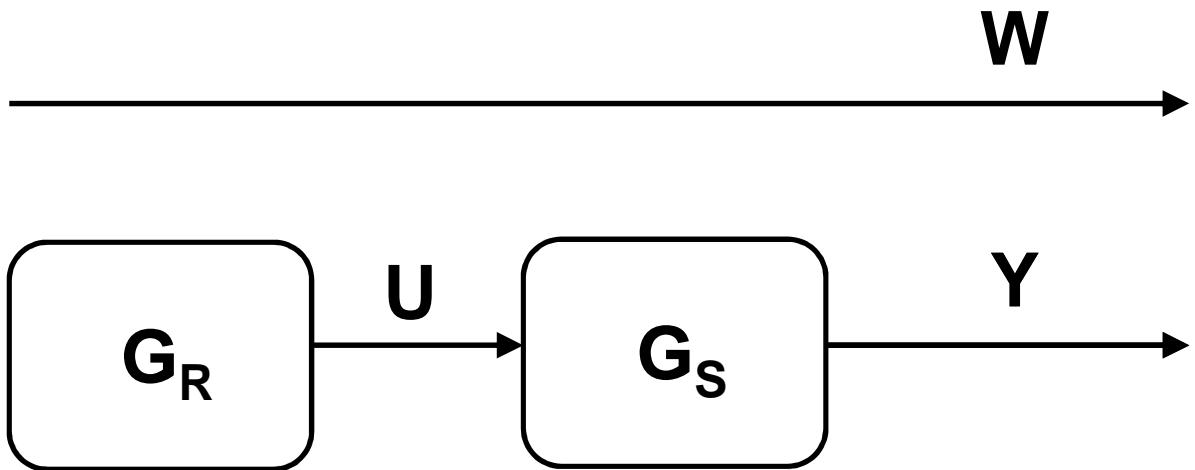
# URO



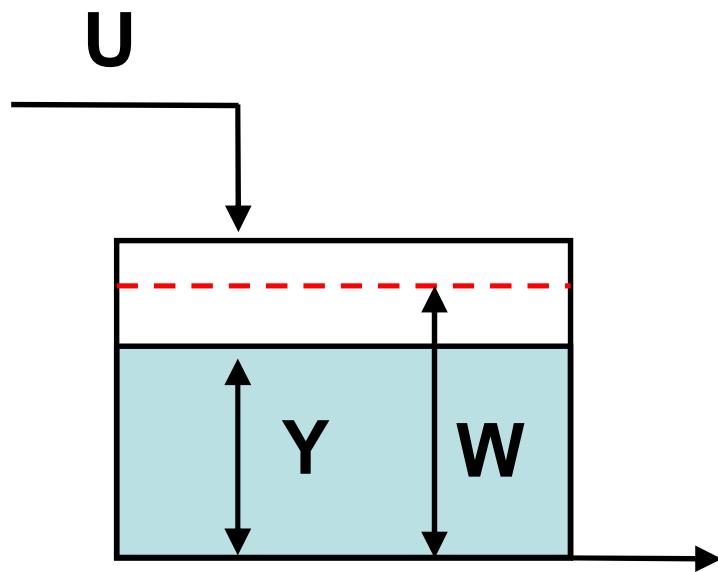
# URO



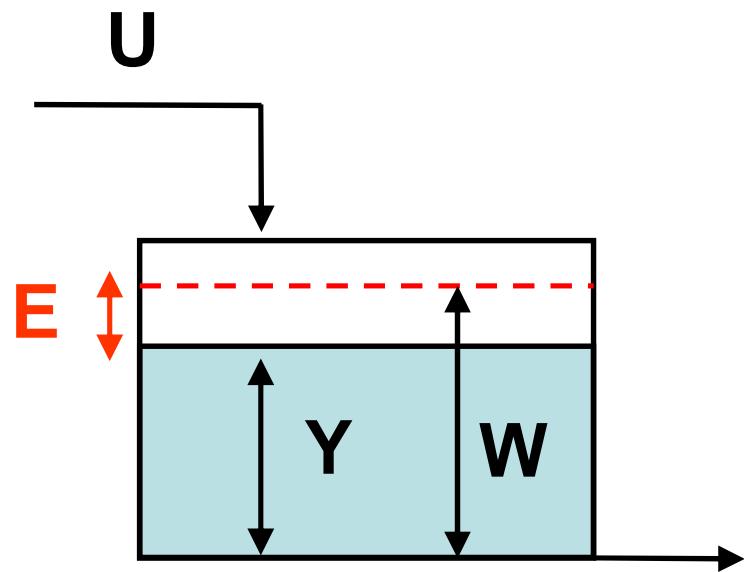
# URO



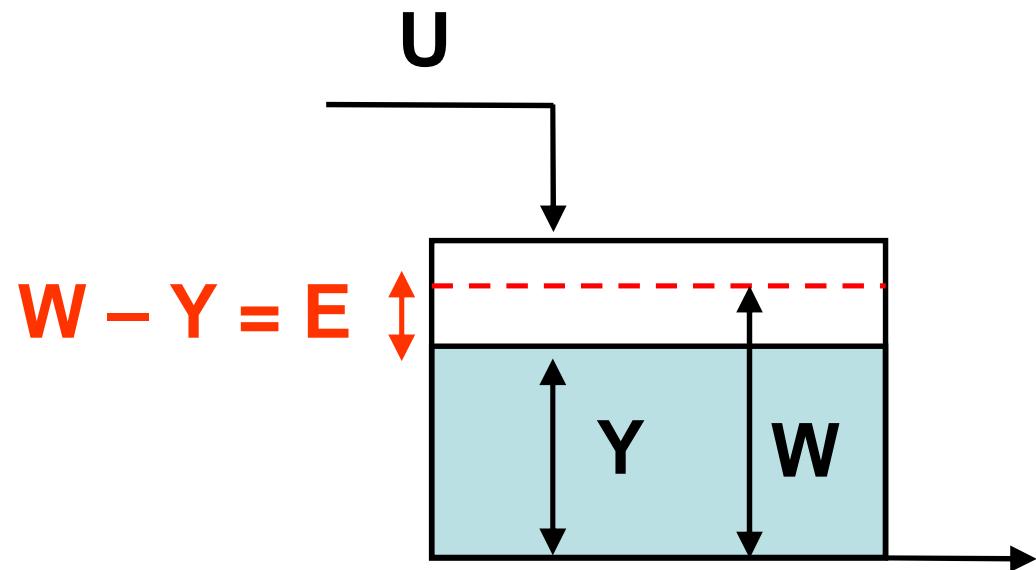
# URO



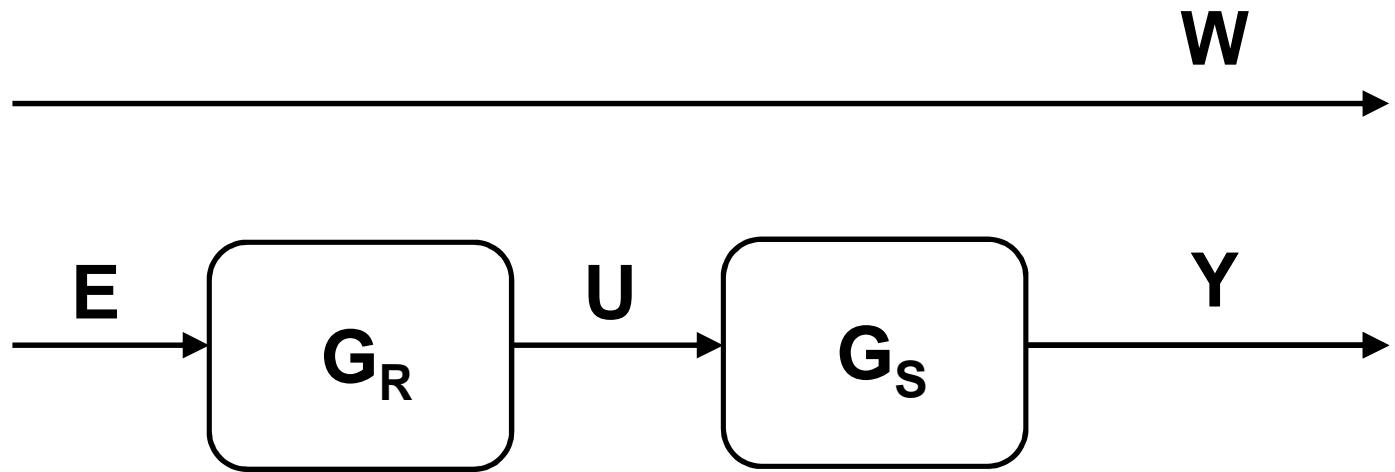
# URO



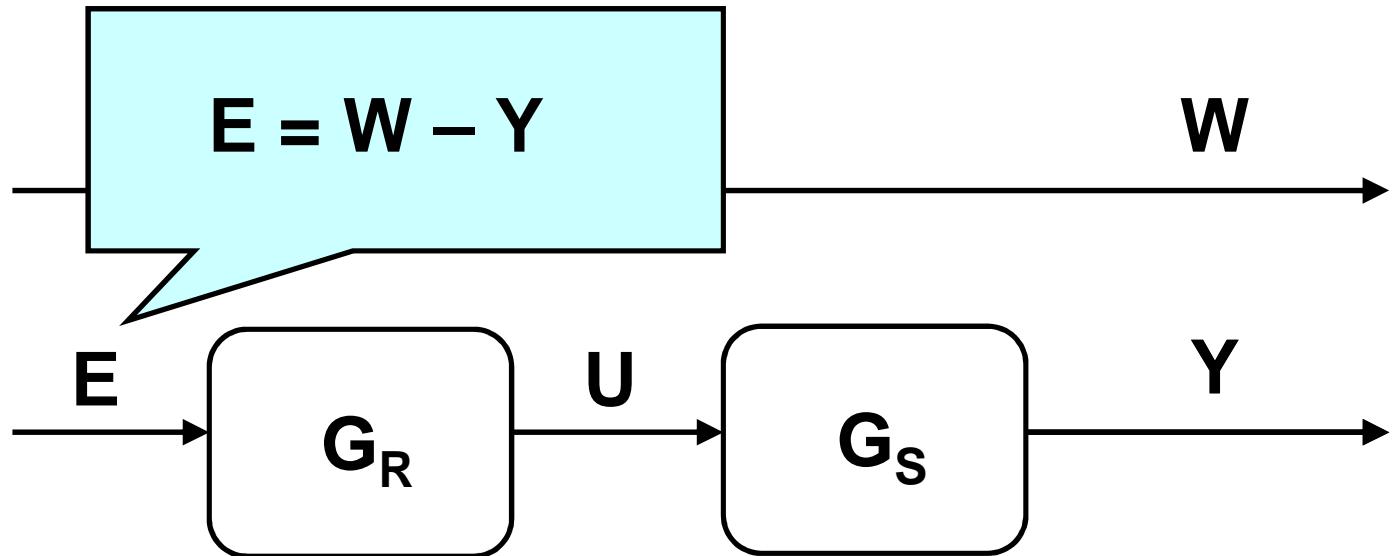
# URO



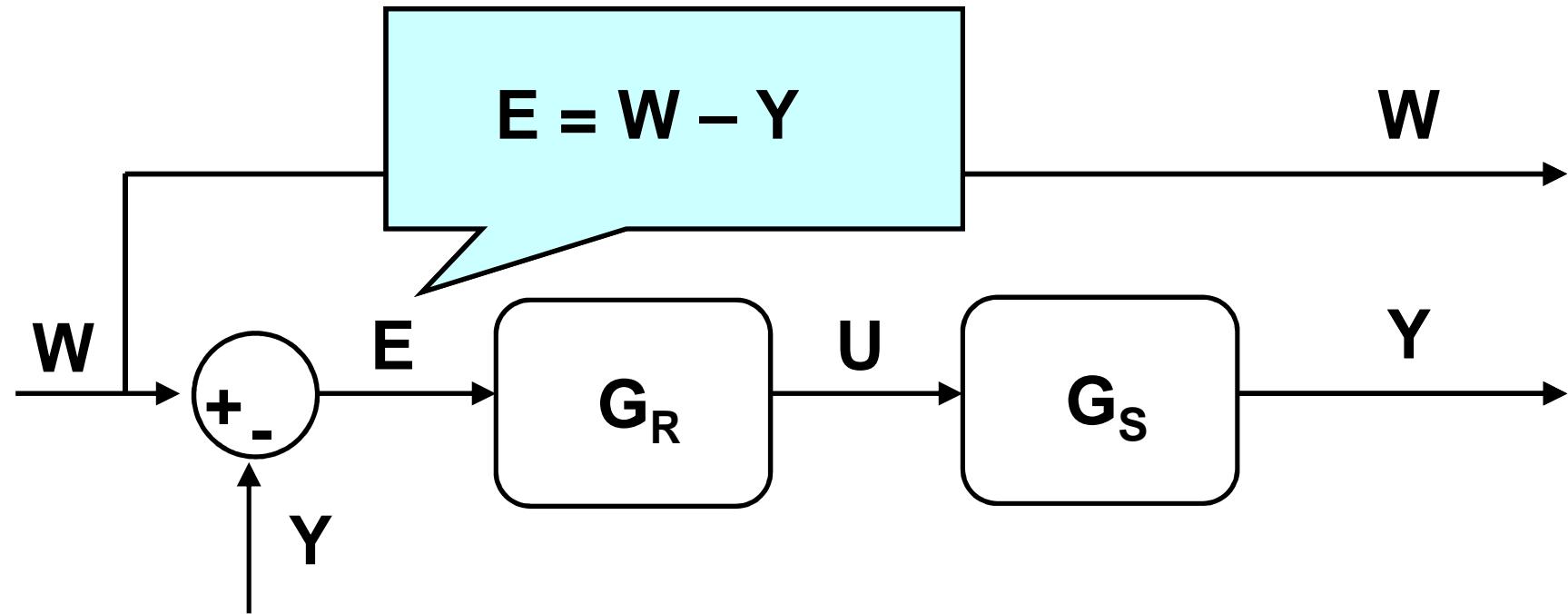
# URO



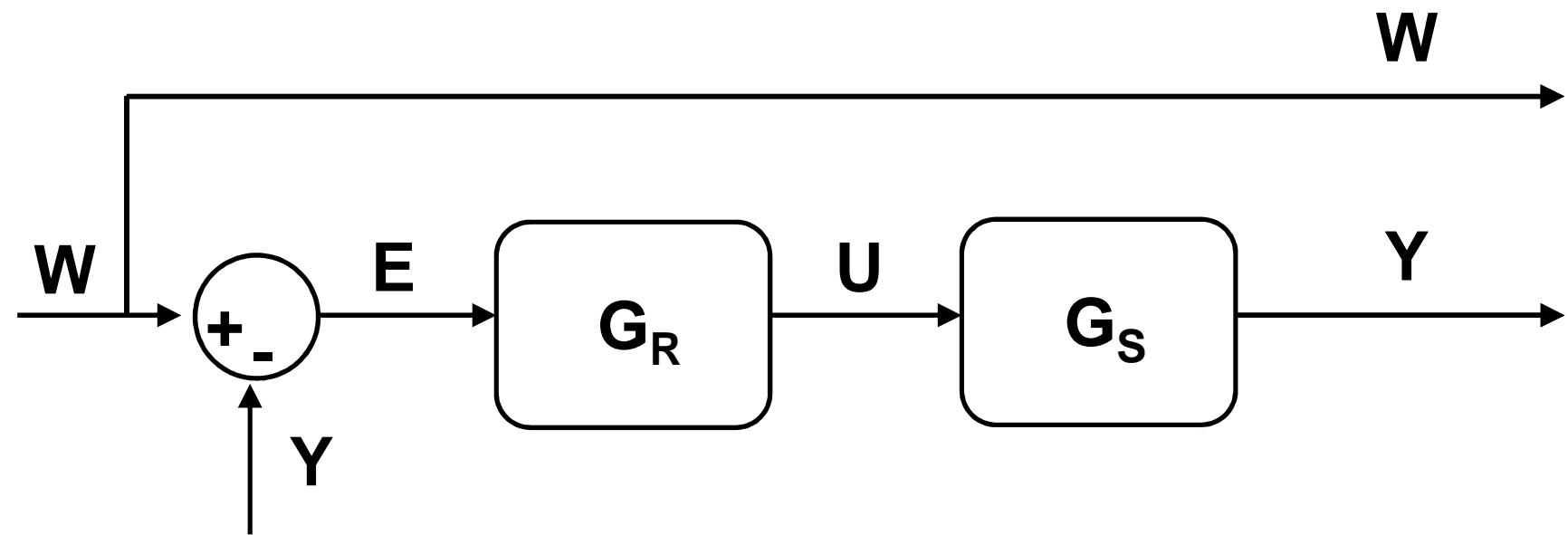
# URO



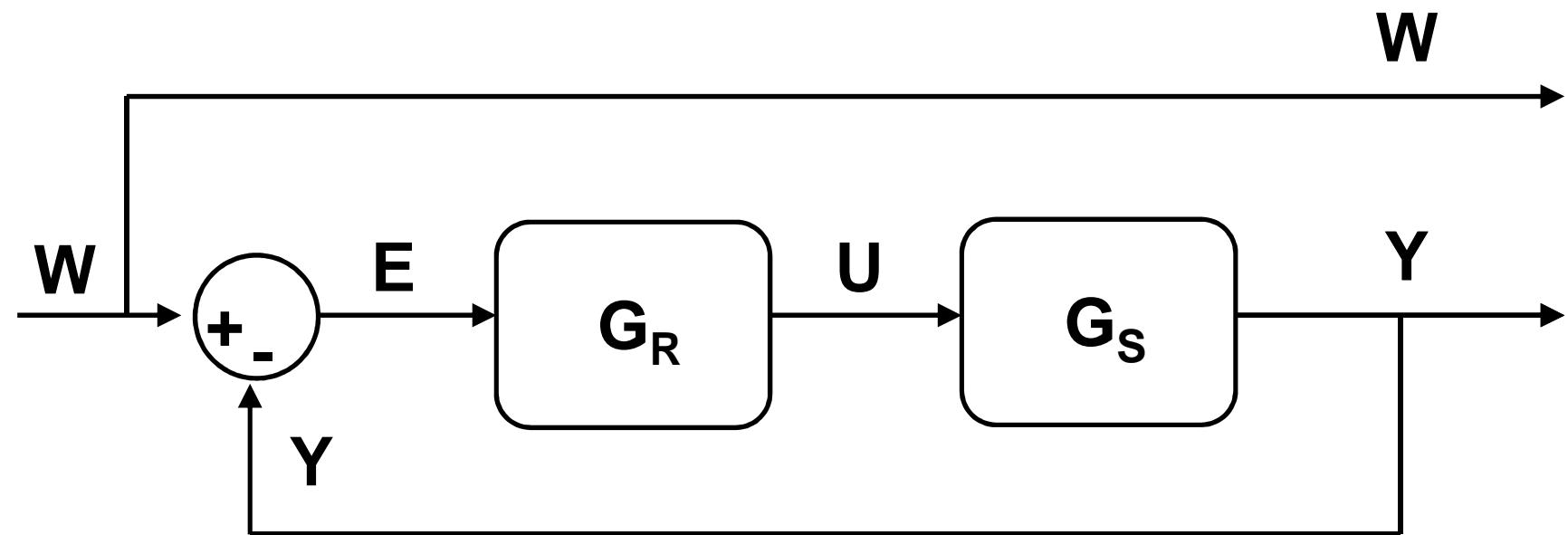
# URO



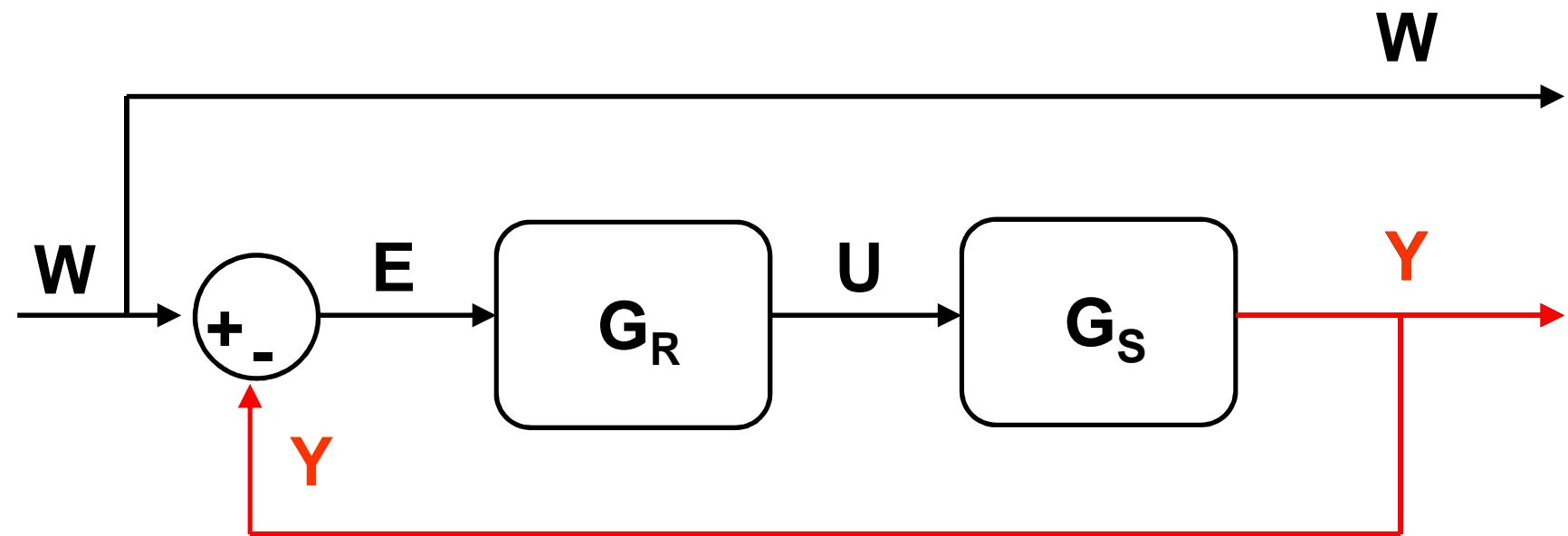
# URO



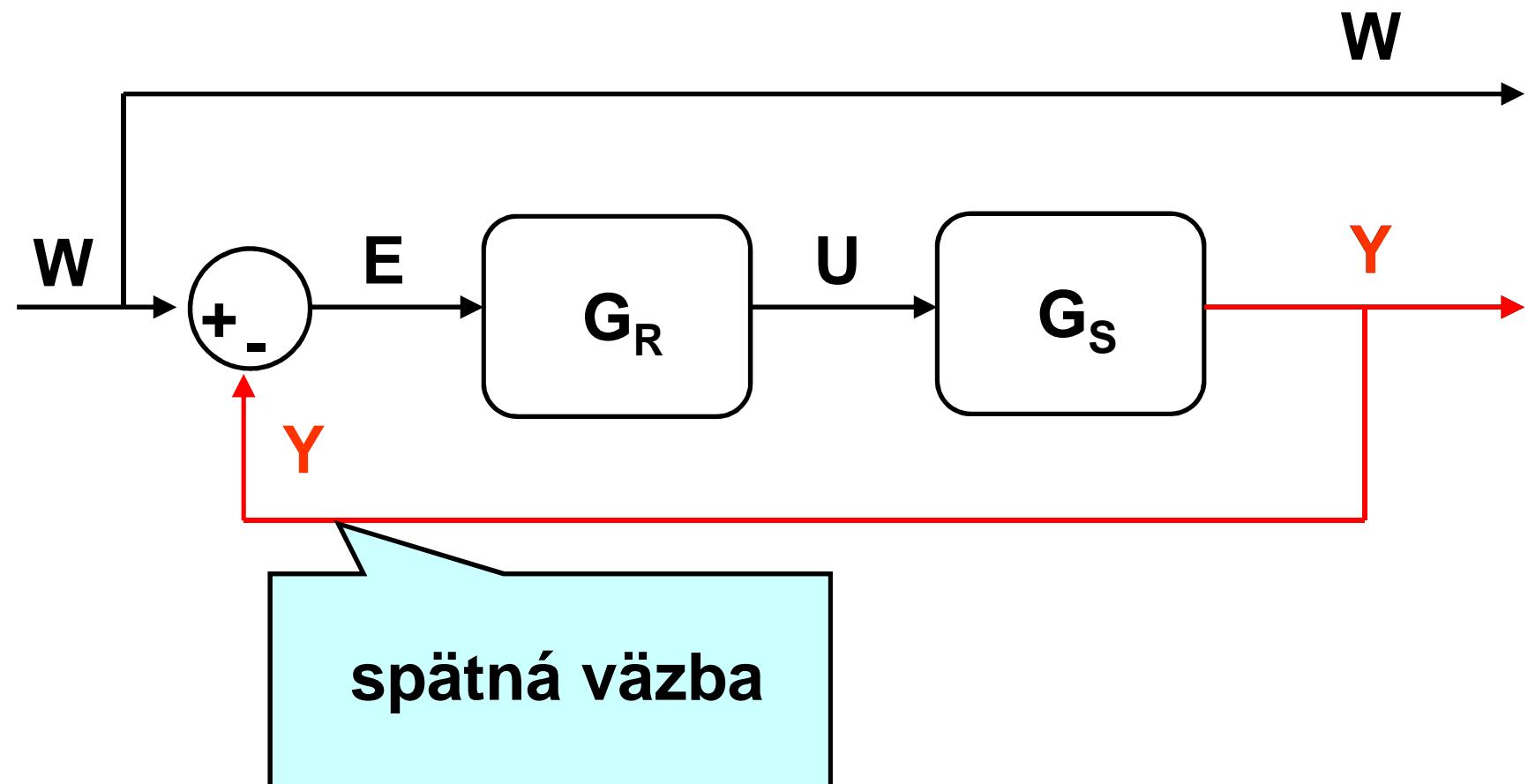
# URO



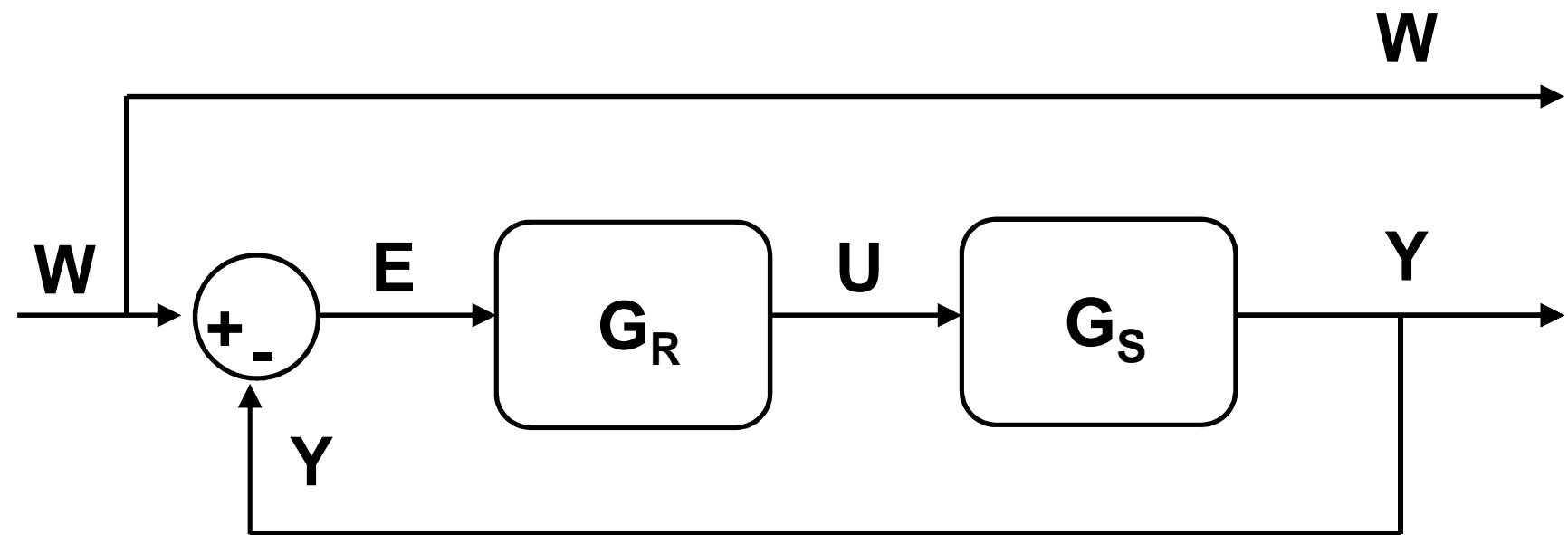
# URO



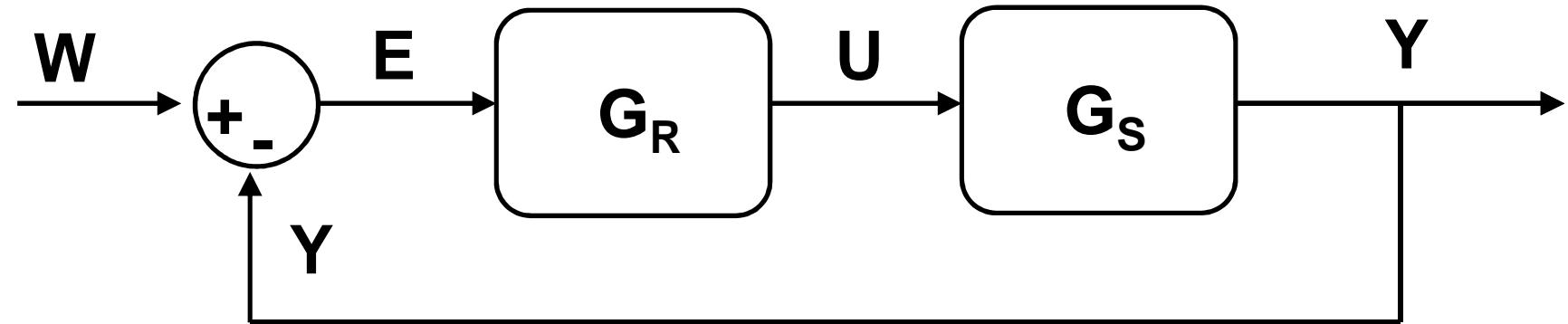
# URO



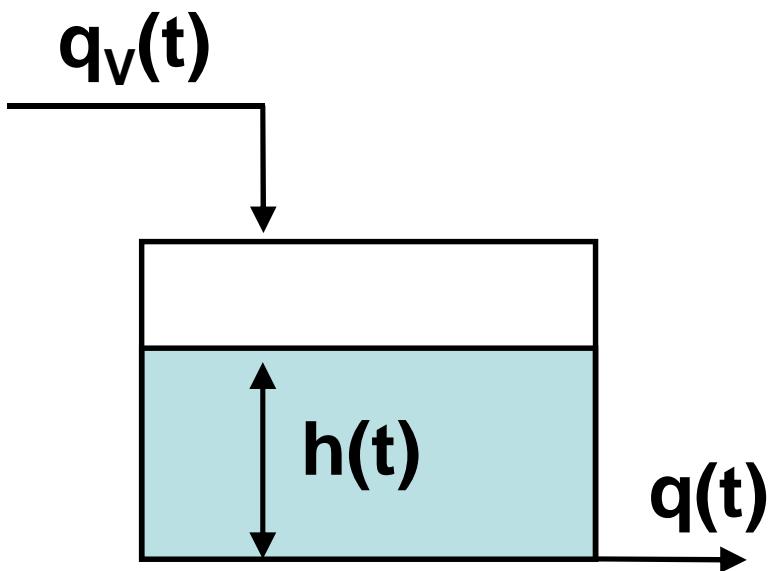
# URO



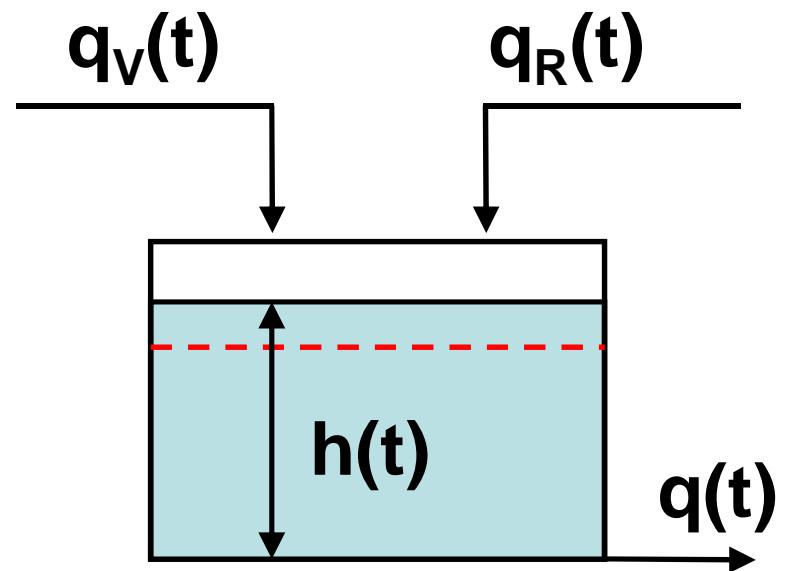
# URO



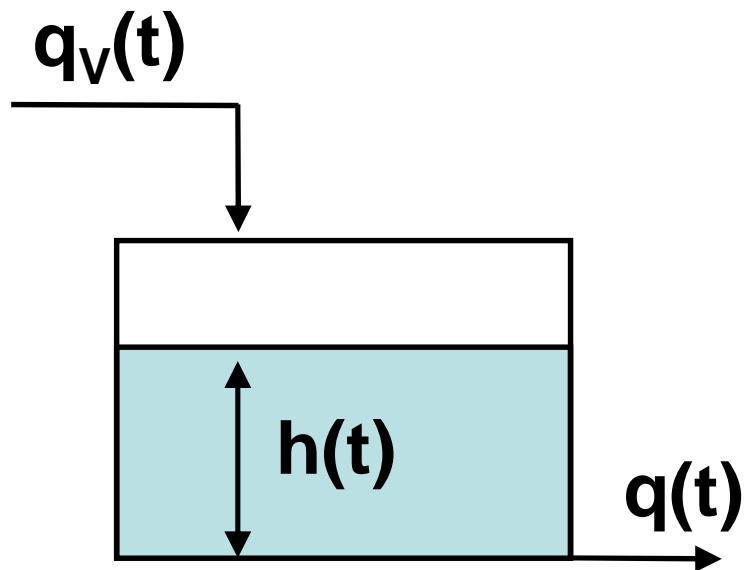
# URO



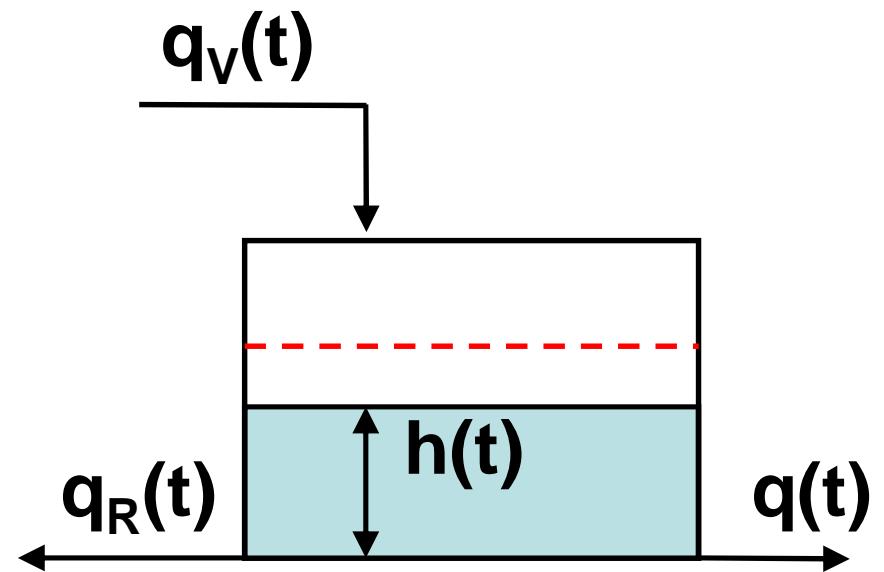
# URO



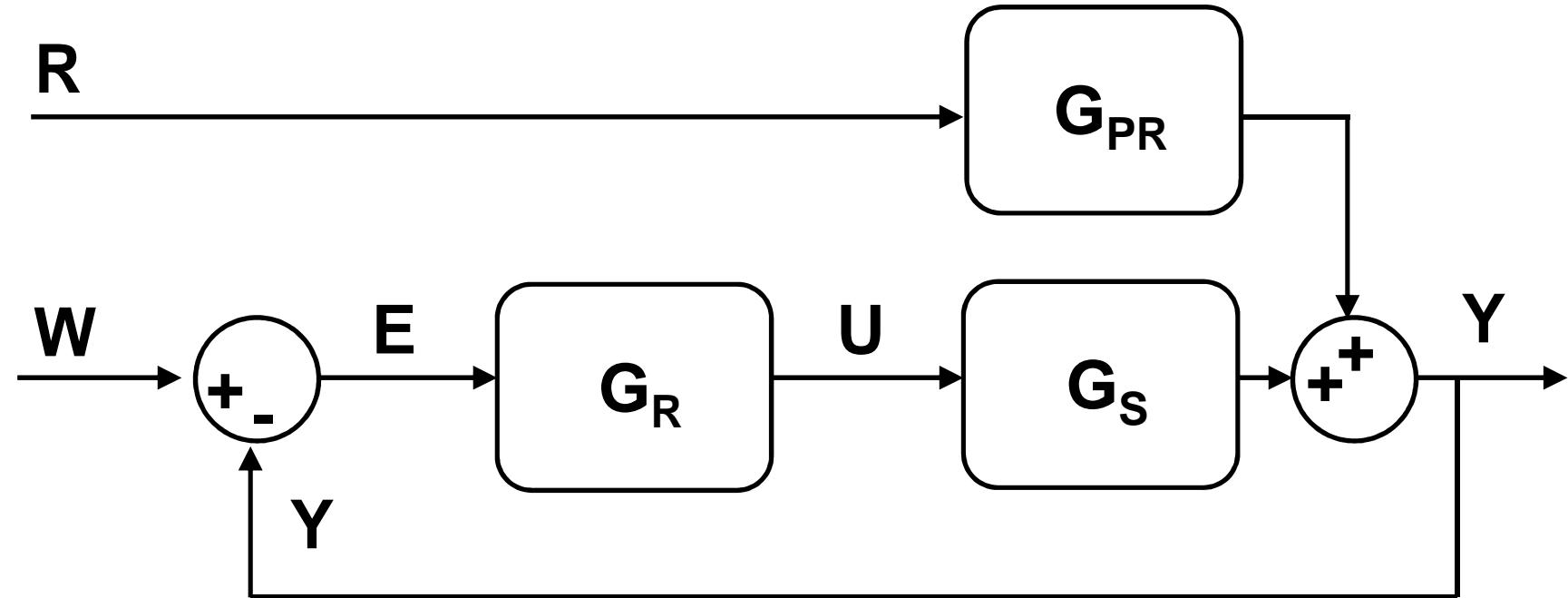
# URO



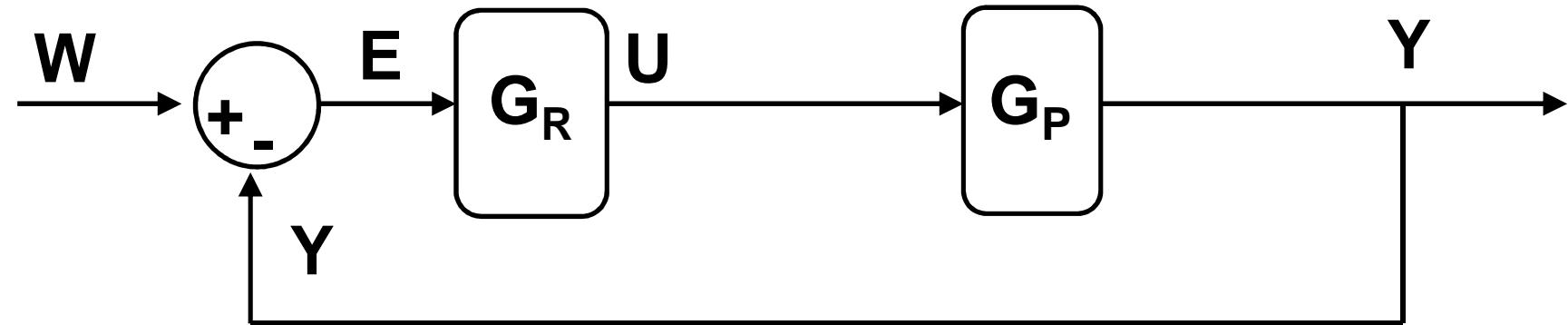
# URO



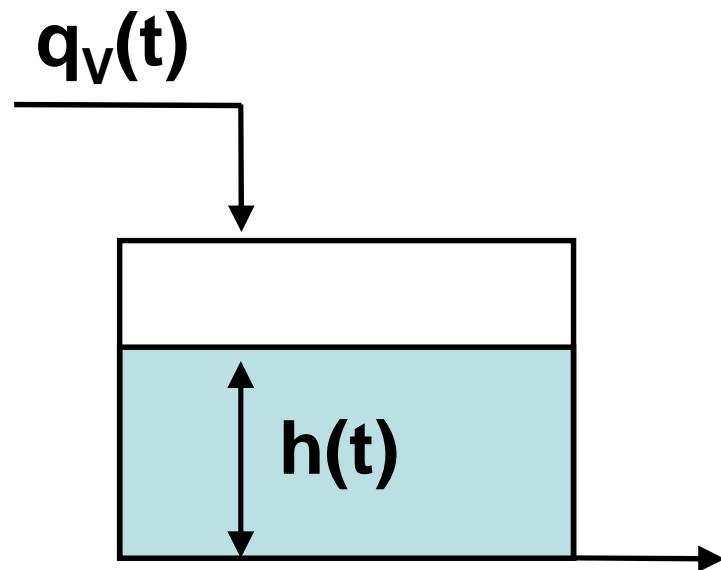
# URO



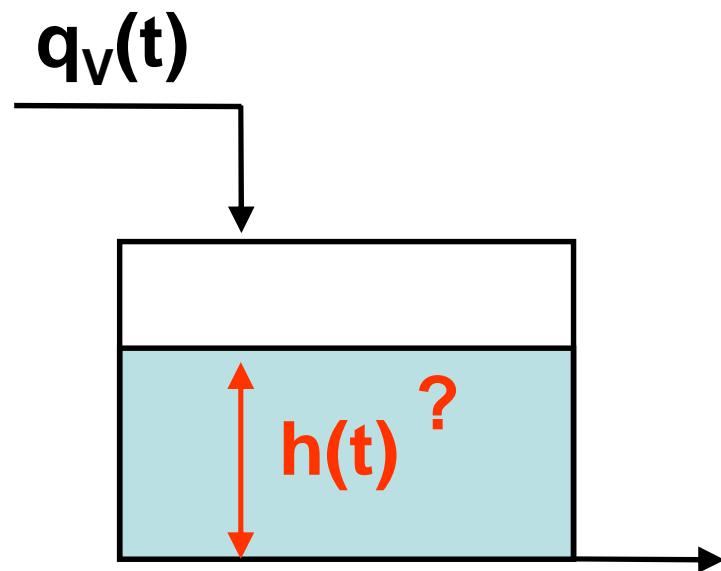
# URO



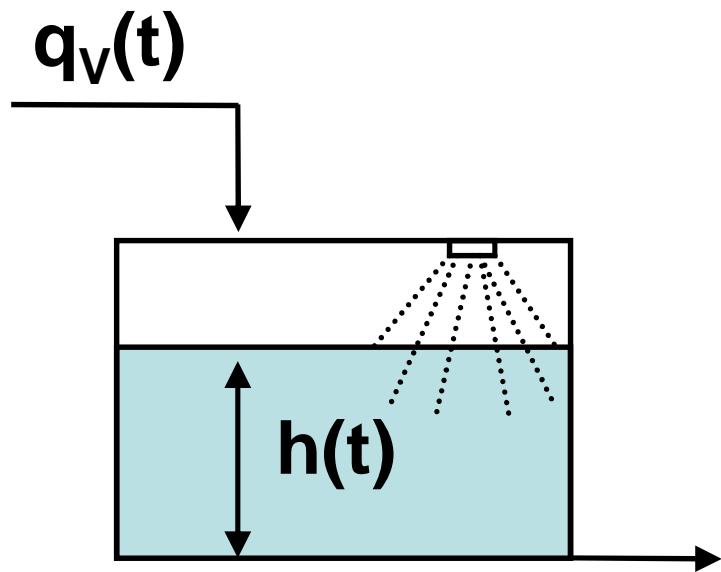
# URO



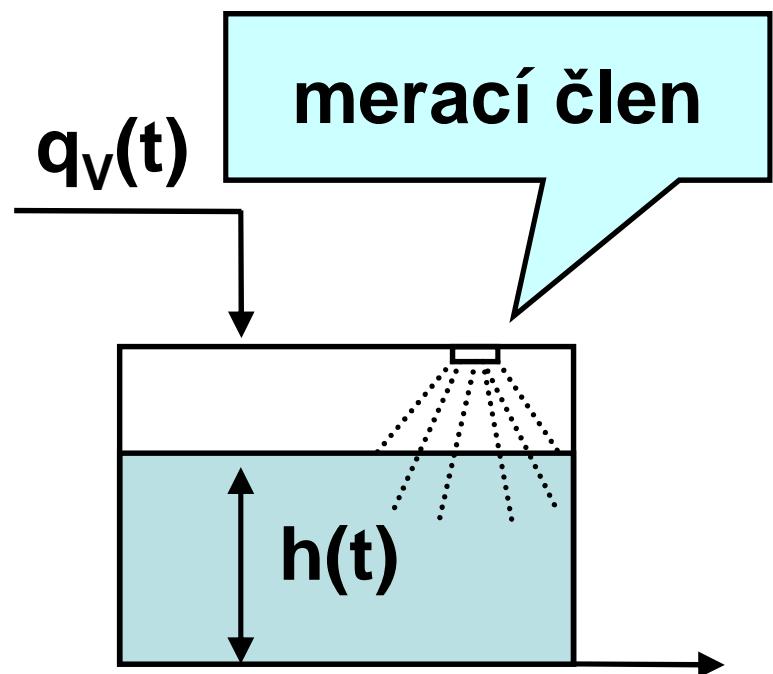
# URO



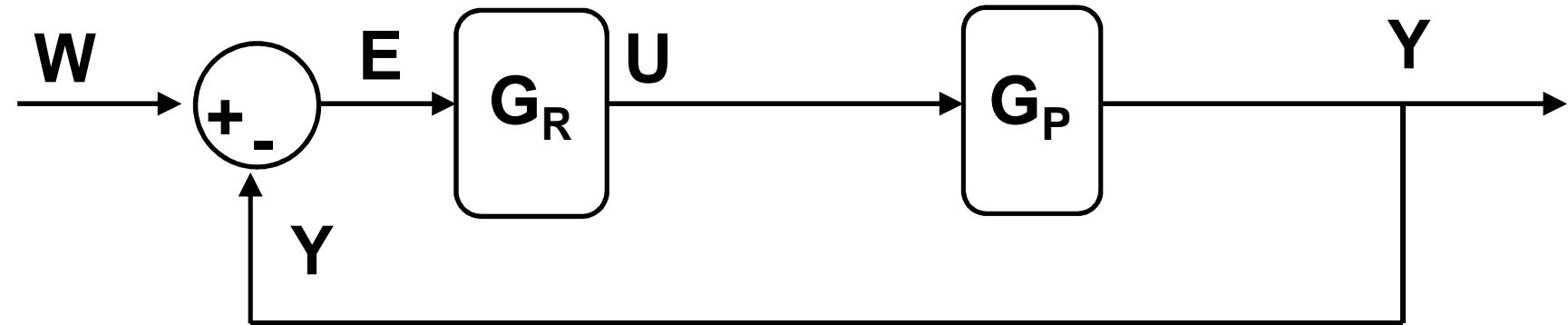
# URO



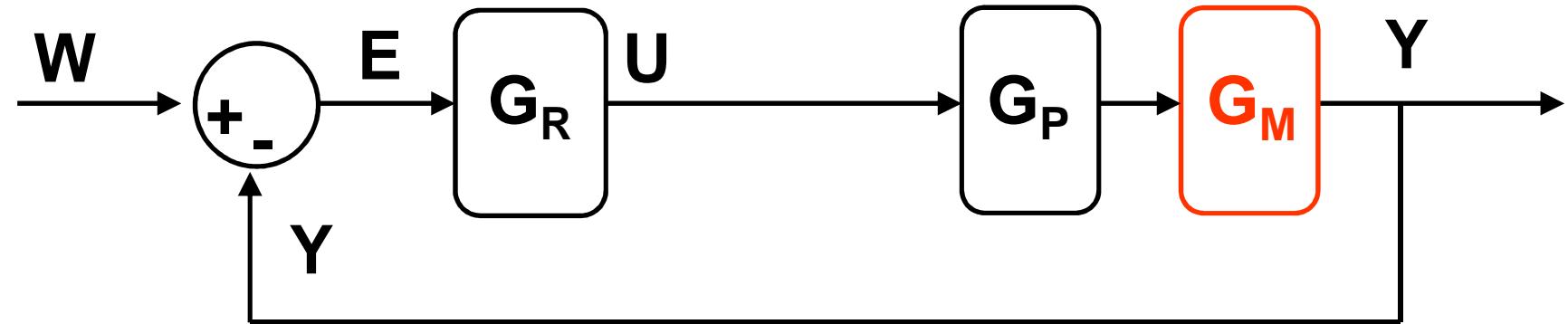
**URO**



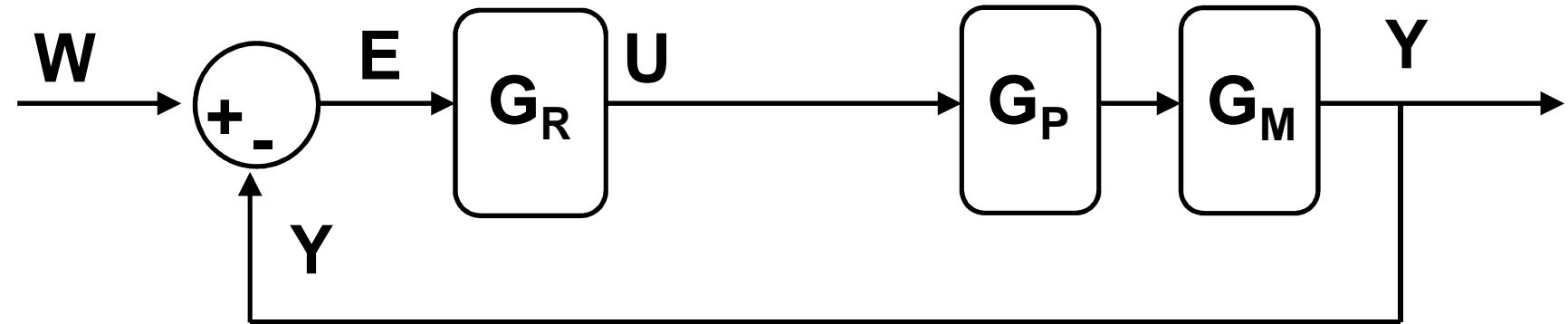
# URO



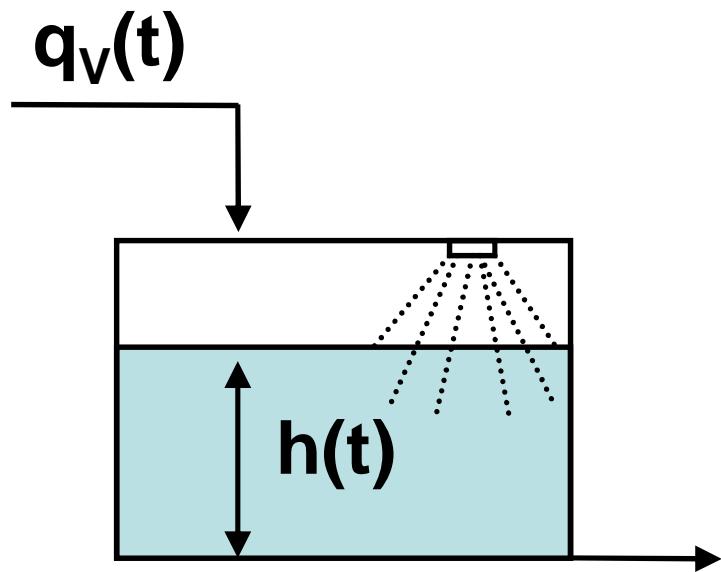
# URO



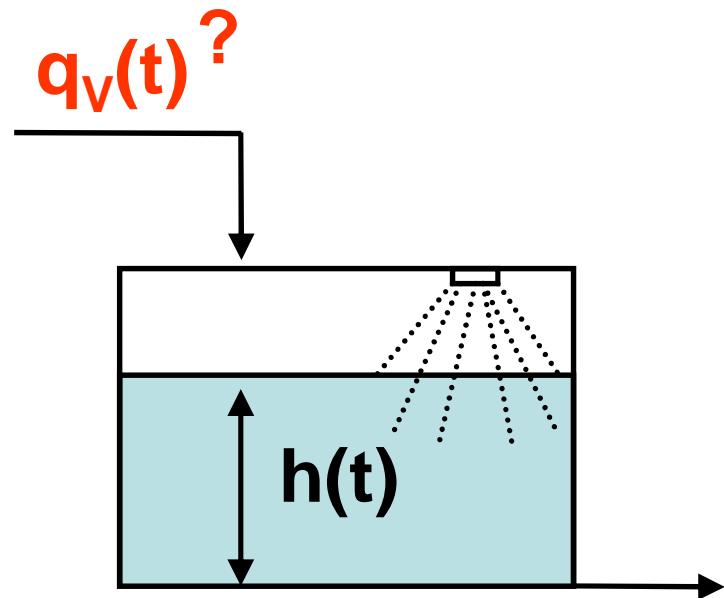
# URO



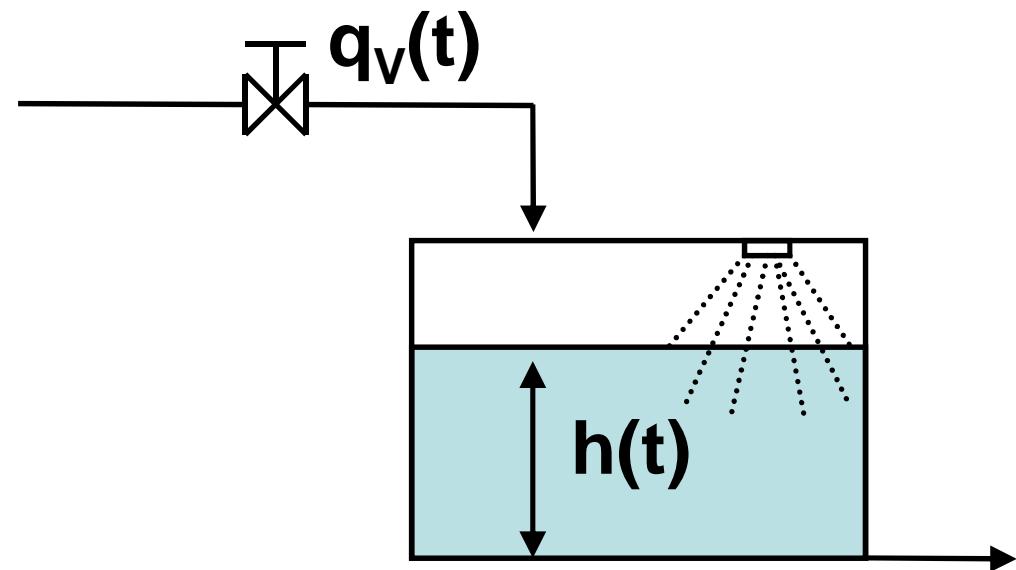
# URO



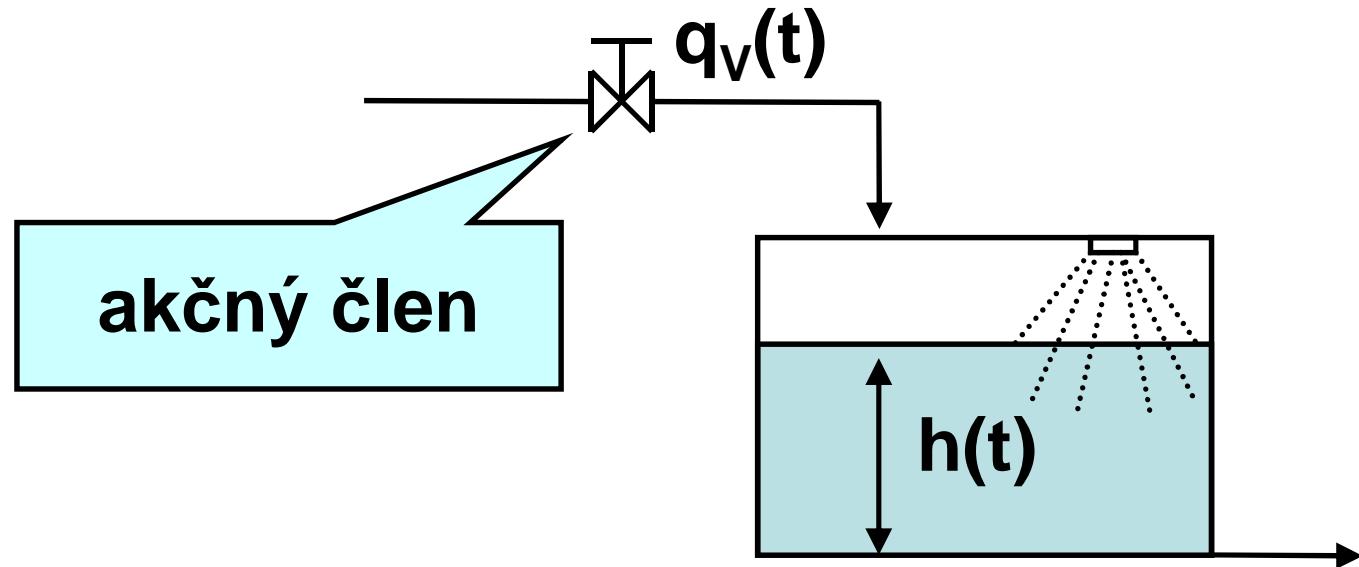
# URO



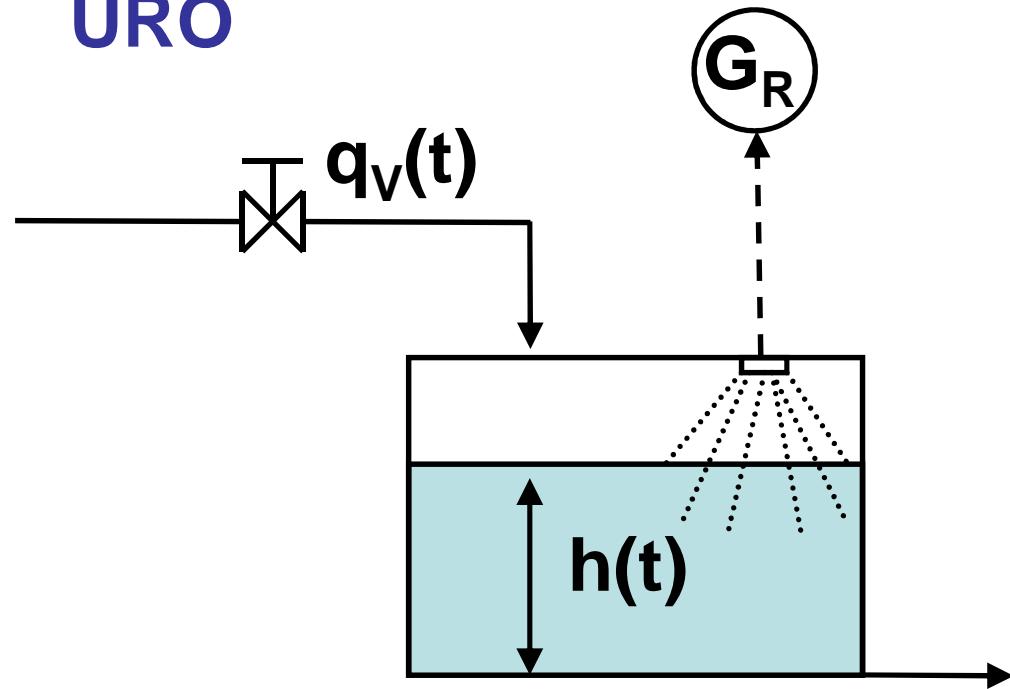
# URO



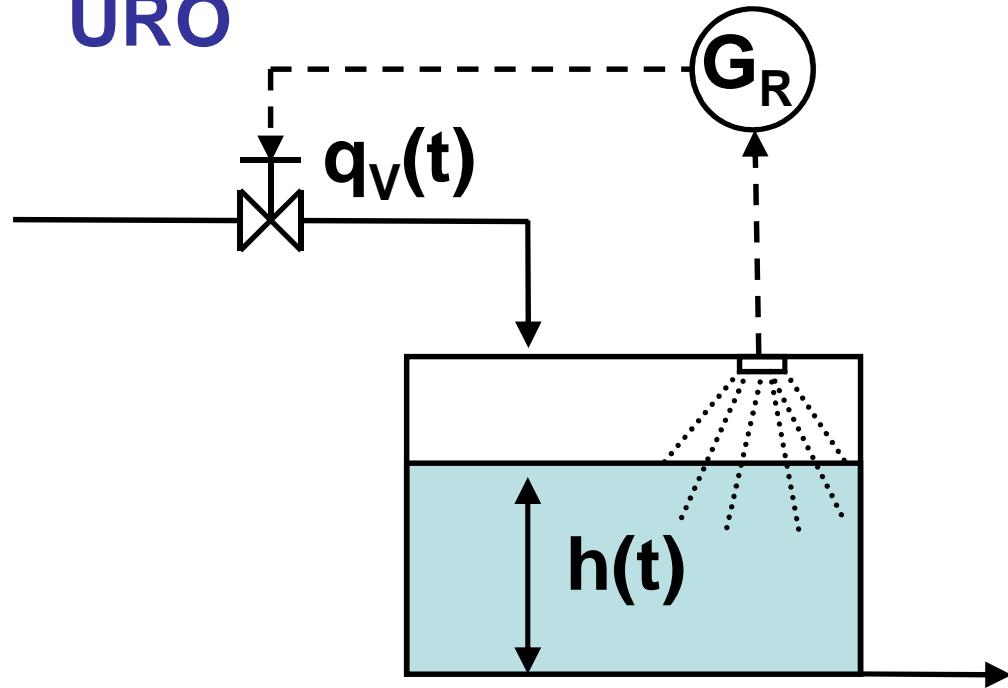
# URO

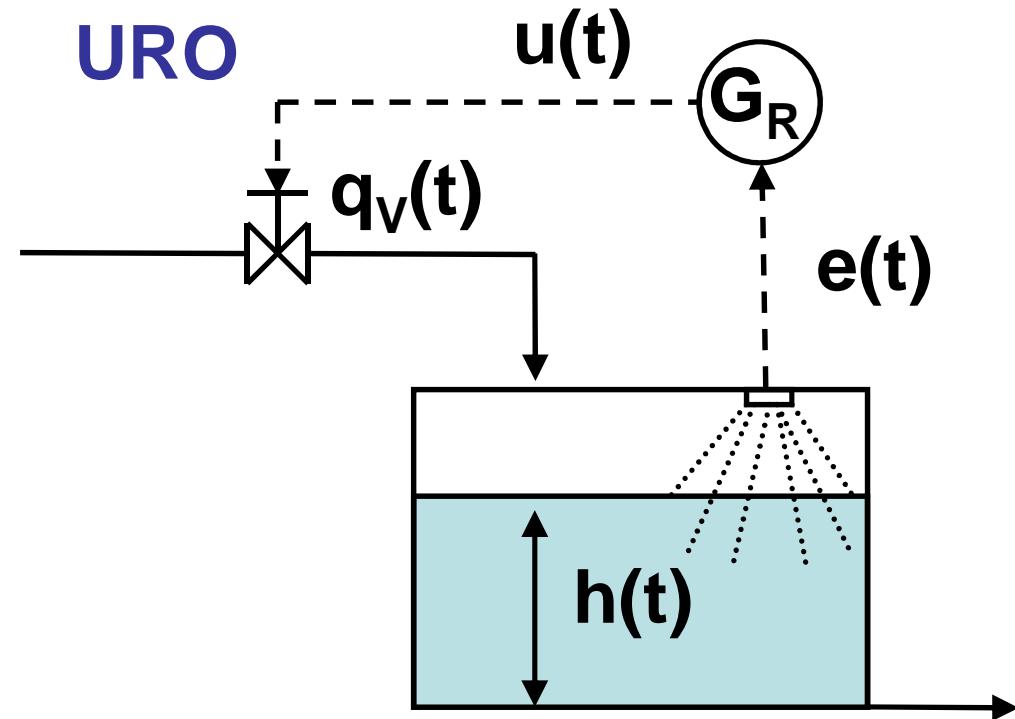


**URO**

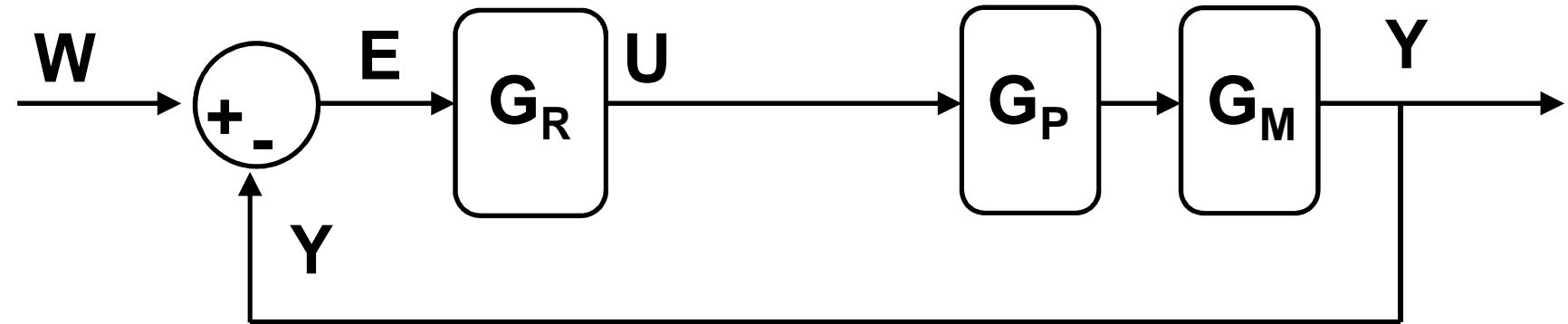


**URO**

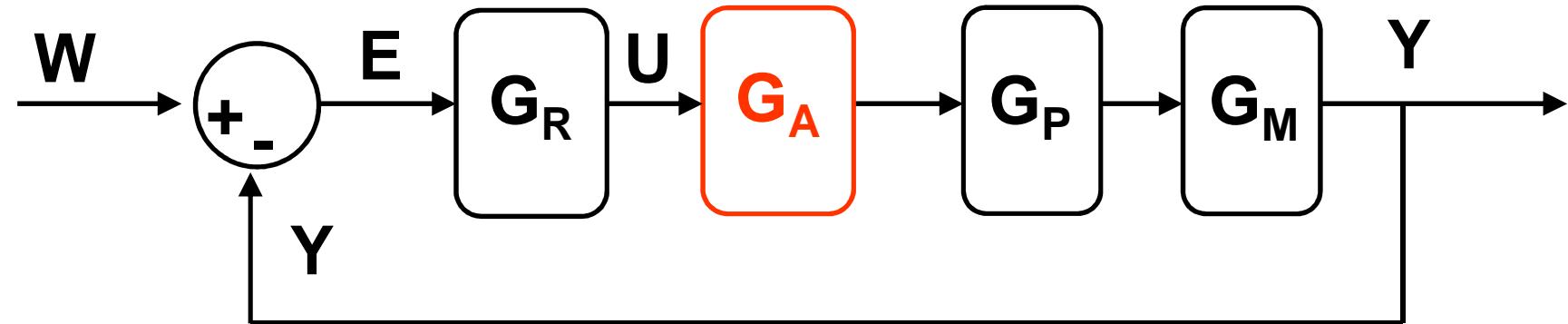




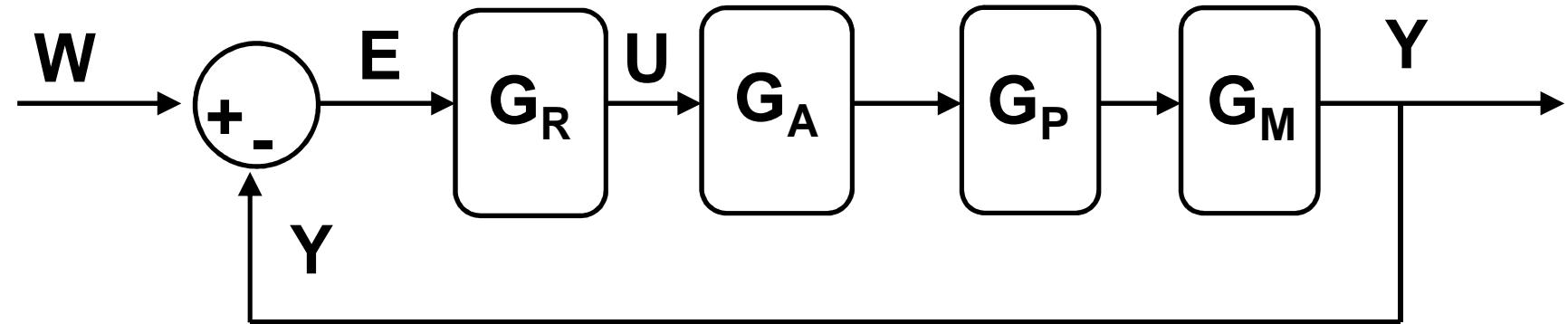
# URO



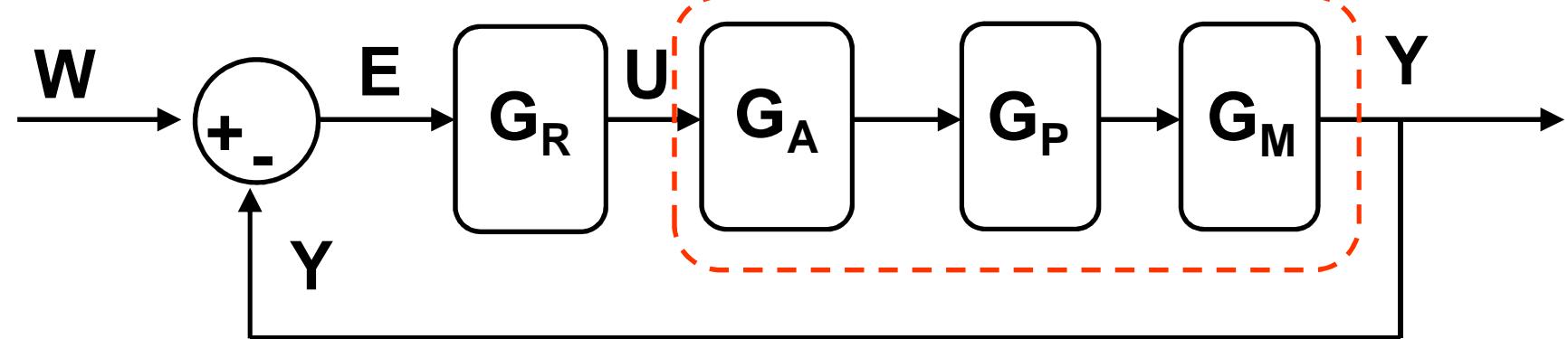
# URO



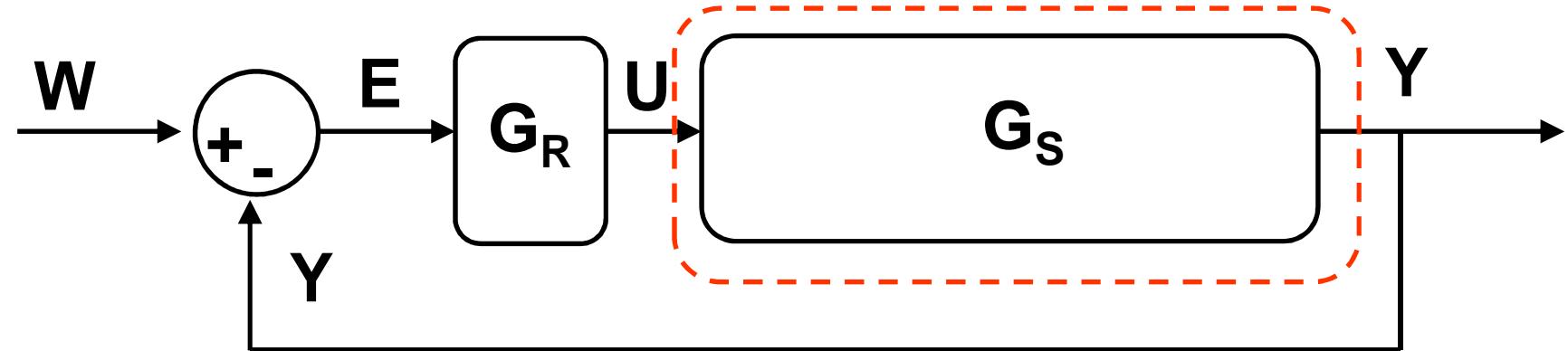
# URO



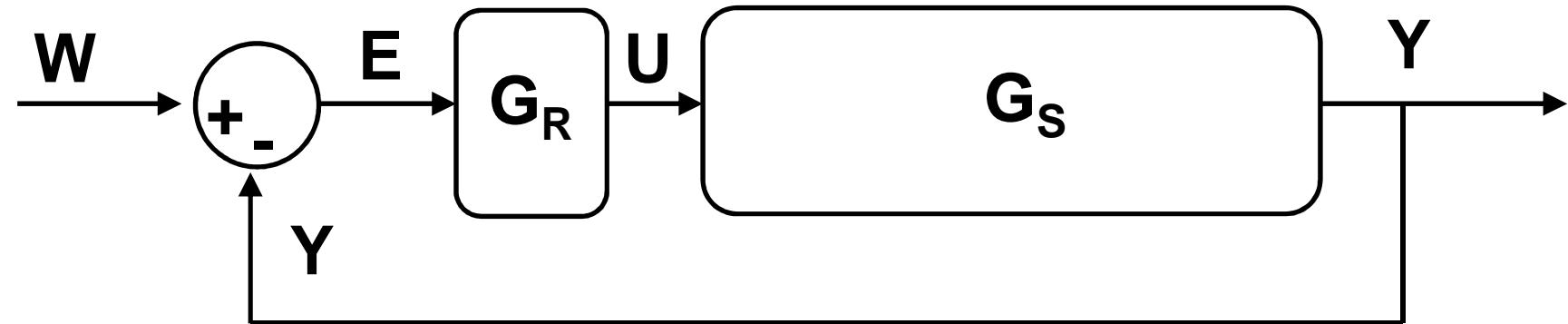
# URO



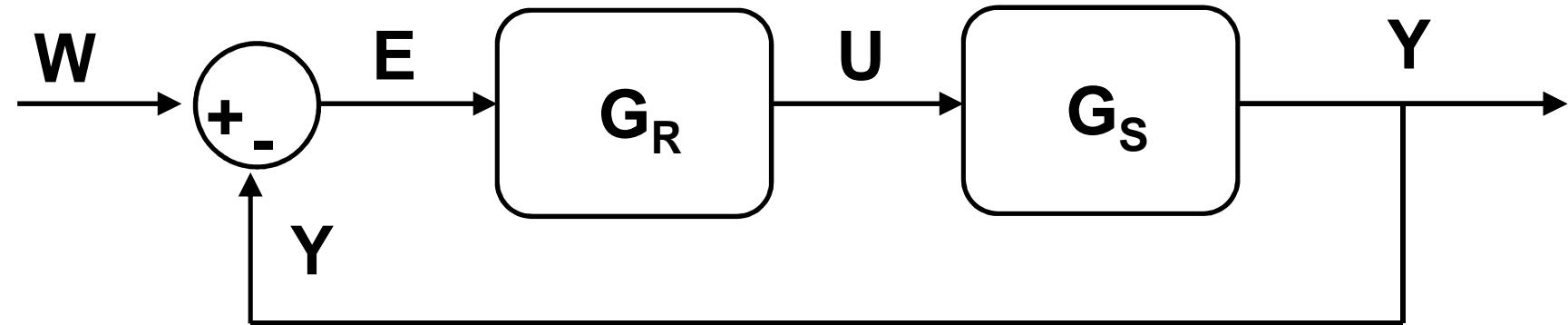
# URO



# URO



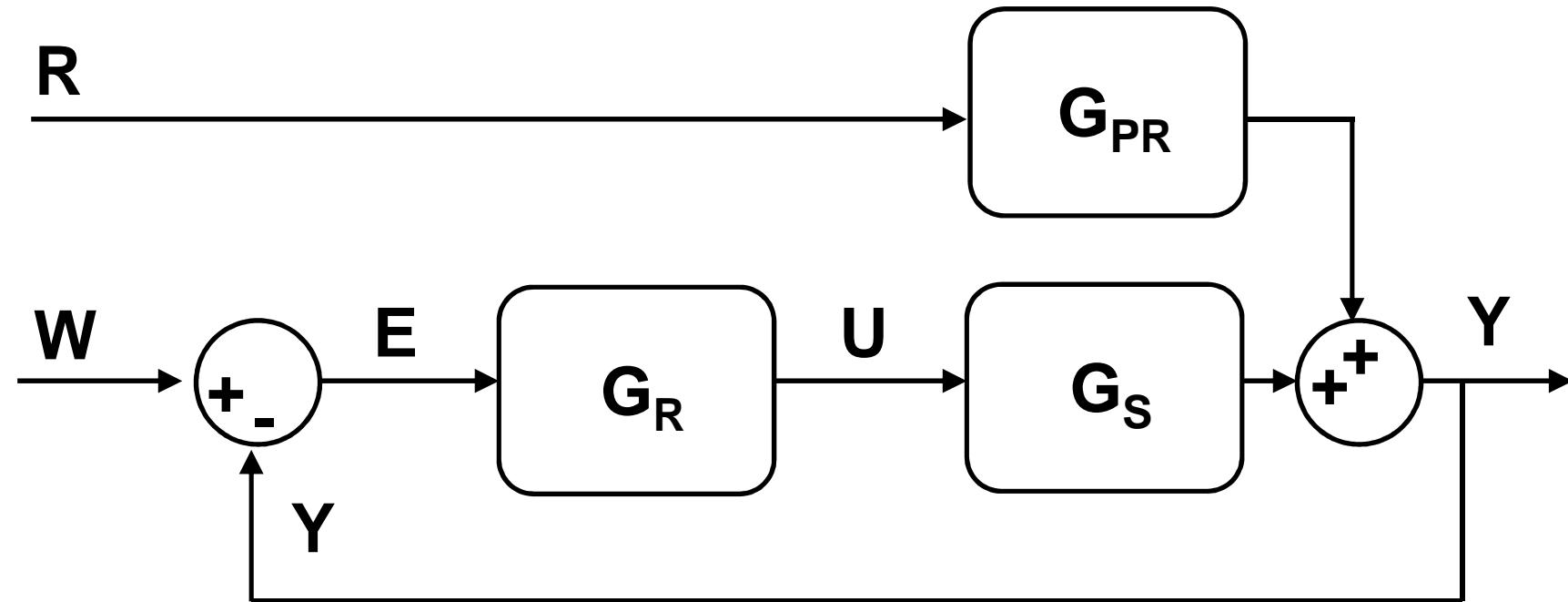
# URO



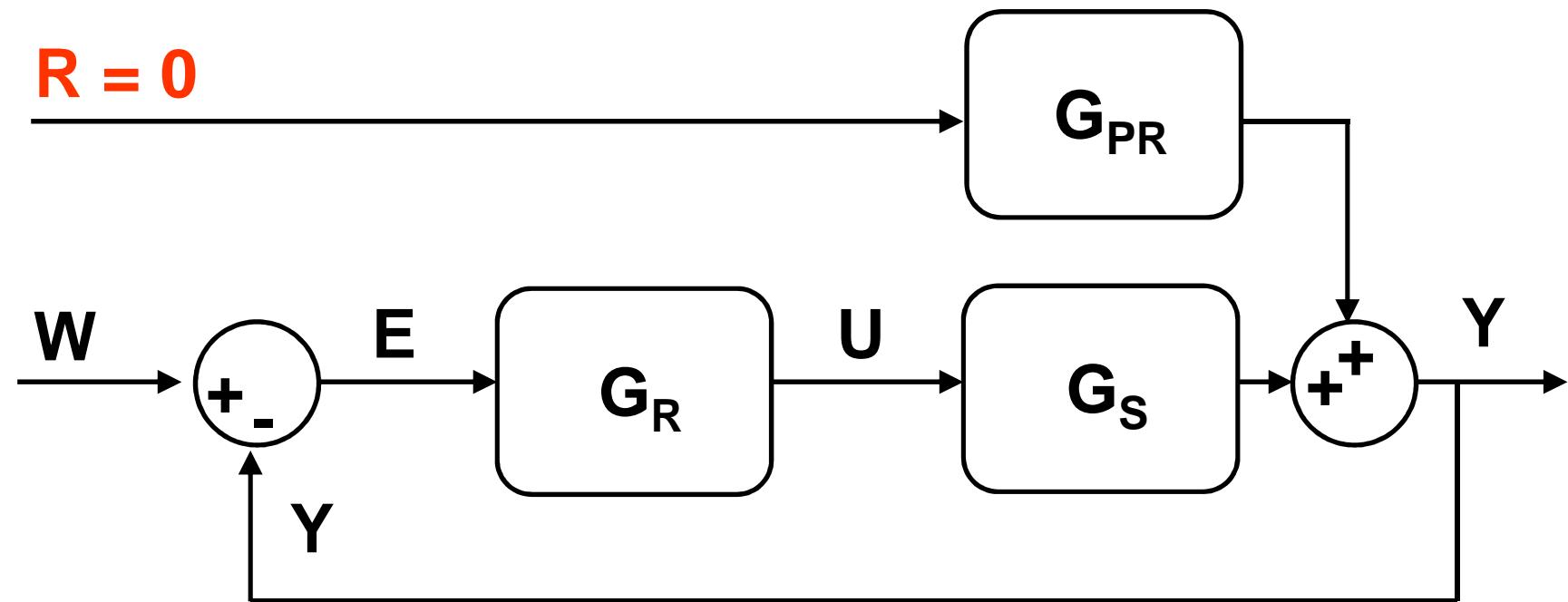
## **7. Zadanie z LCRP – teoretická časť**

- URO
- prenos URO
- CHR URO
- zákon riadenia
- Routhovo-Schurovo kritérium stabilitu

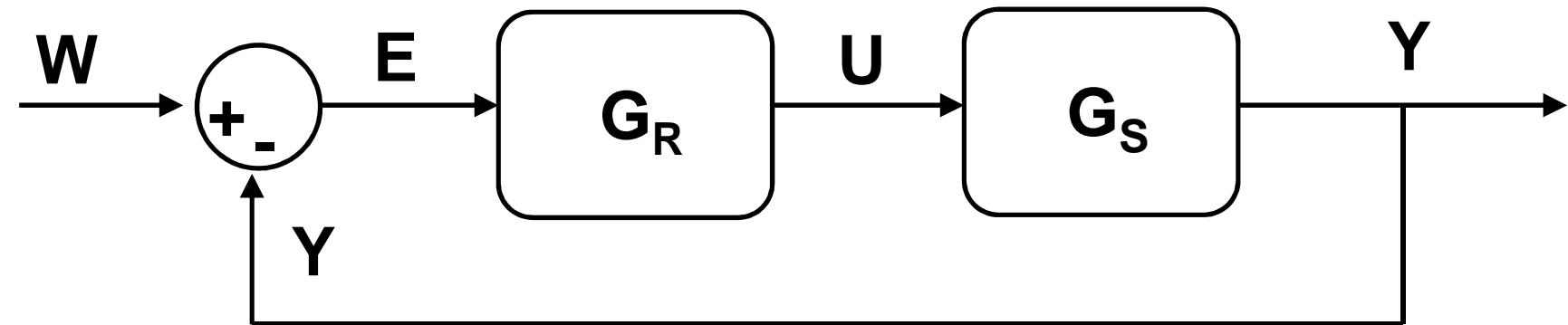
# Prenos URO



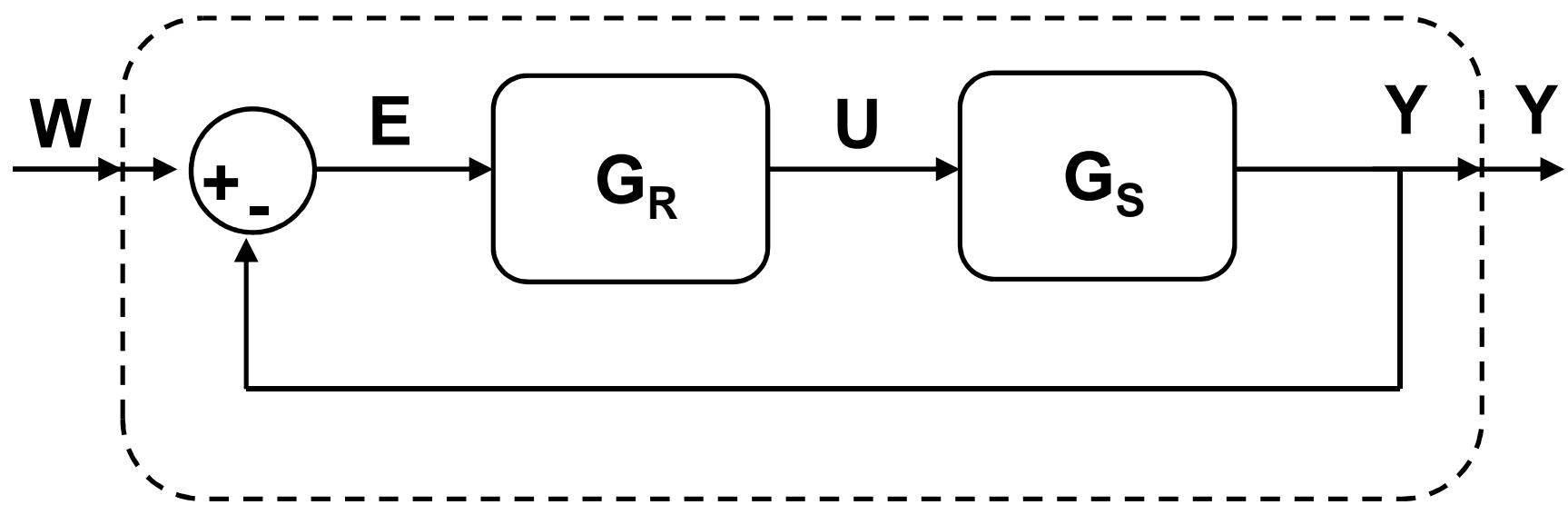
# Prenos URO



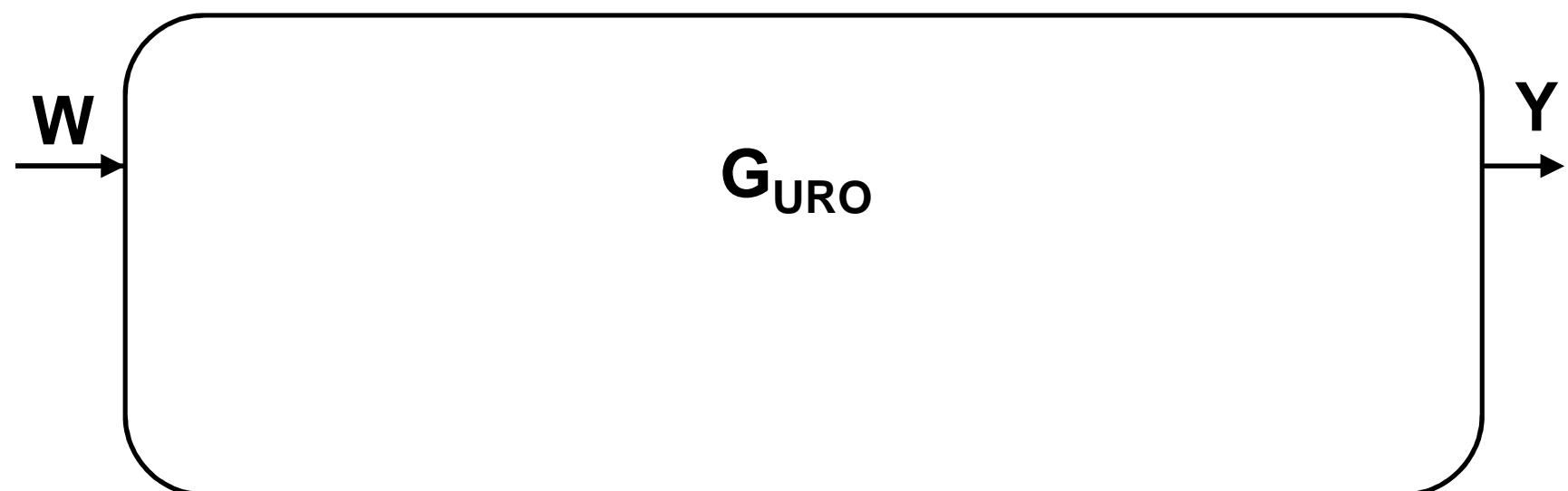
# Prenos URO



# Prenos URO



# Prenos URO



# Prenos URO



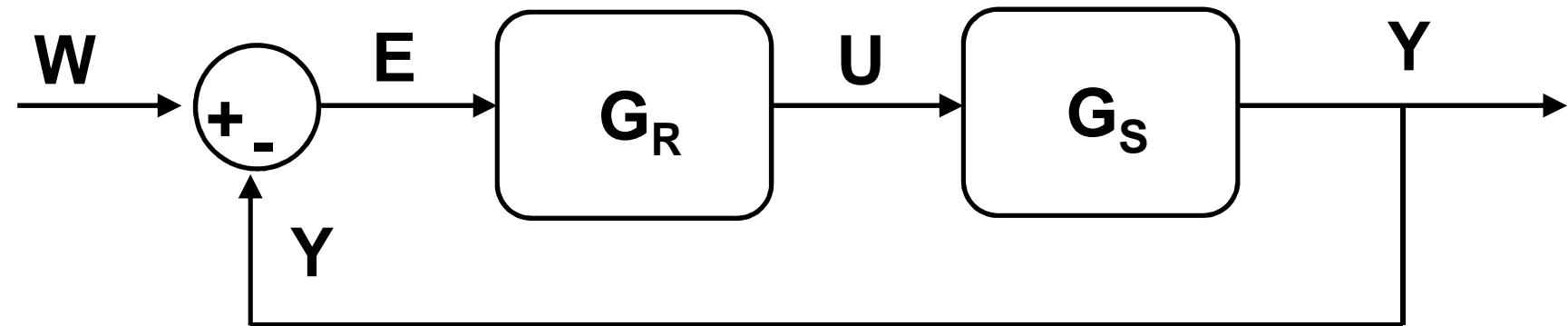
$$Y = G_{URO}W$$

# Prenos URO



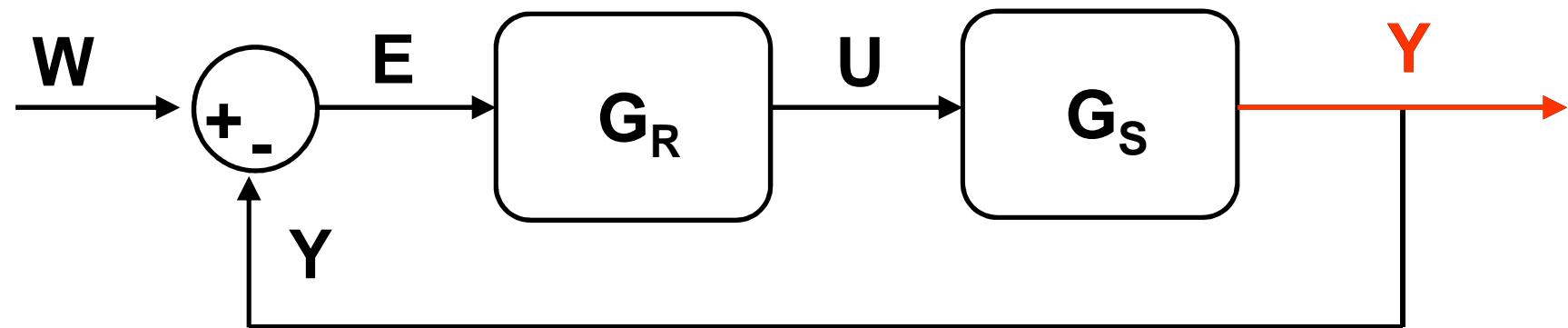
$$Y = G_{URO}^? W$$

# Prenos URO



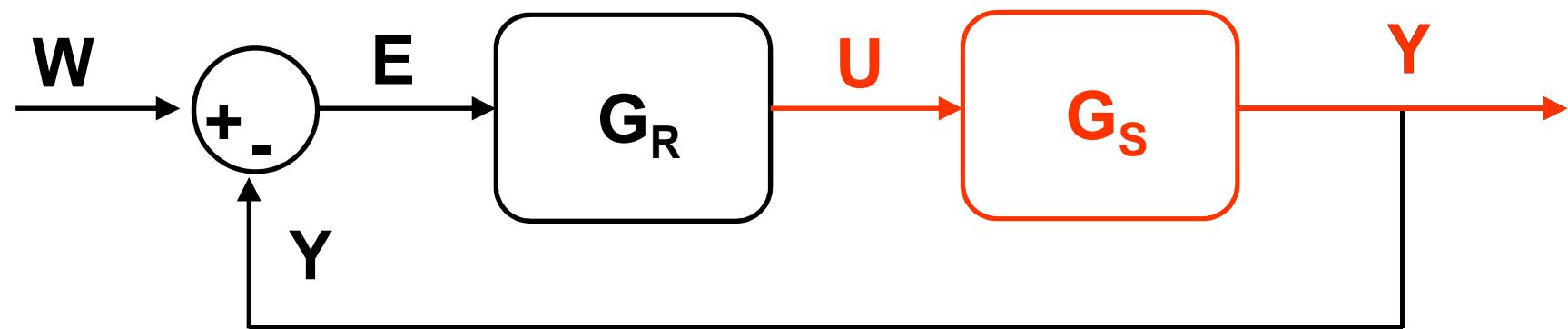
$$Y = G_{URO}^? W$$

# Prenos URO



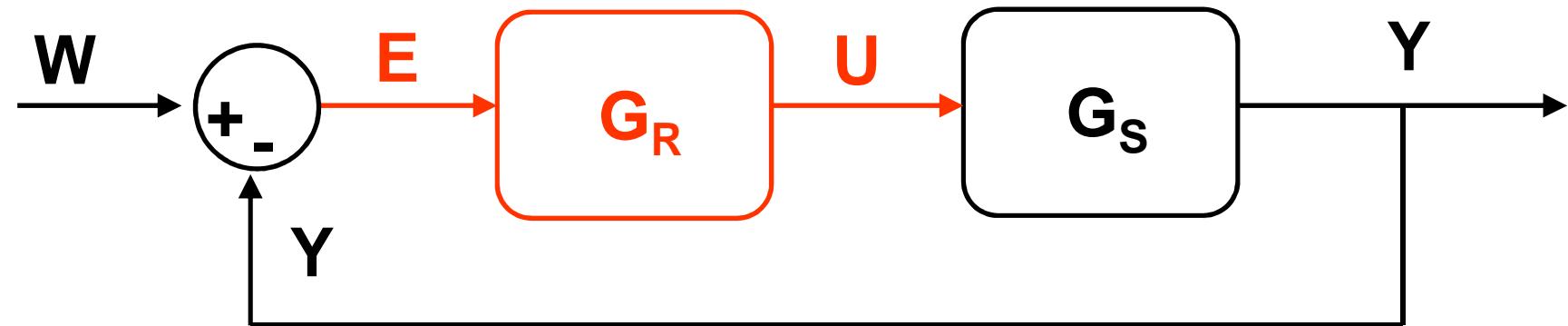
$Y$

# Prenos URO



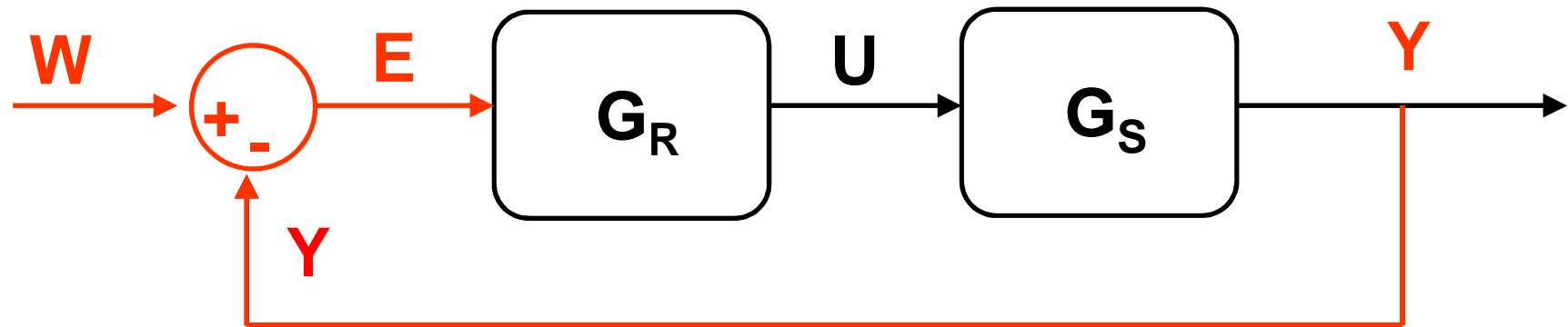
$$Y = G_S U$$

# Prenos URO



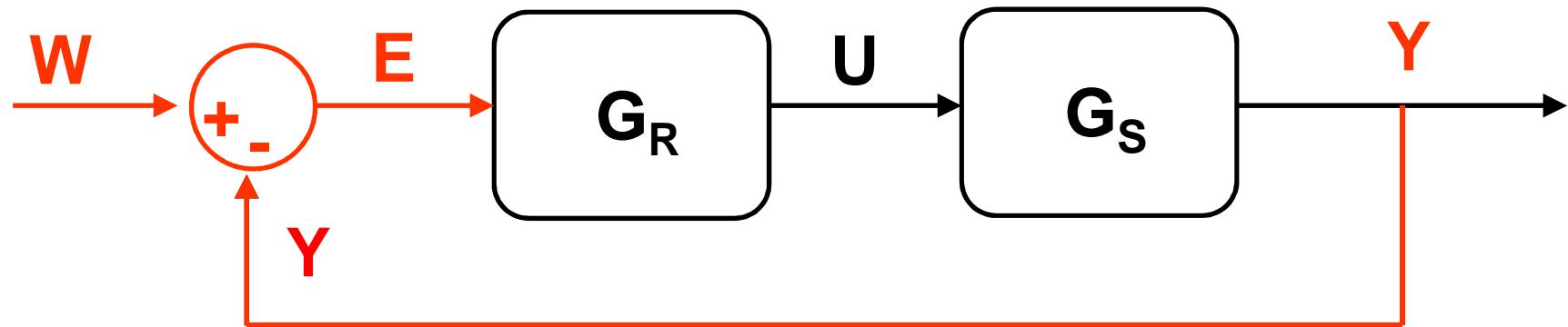
$$Y = G_S U = G_S G_R E$$

## Prenos URO



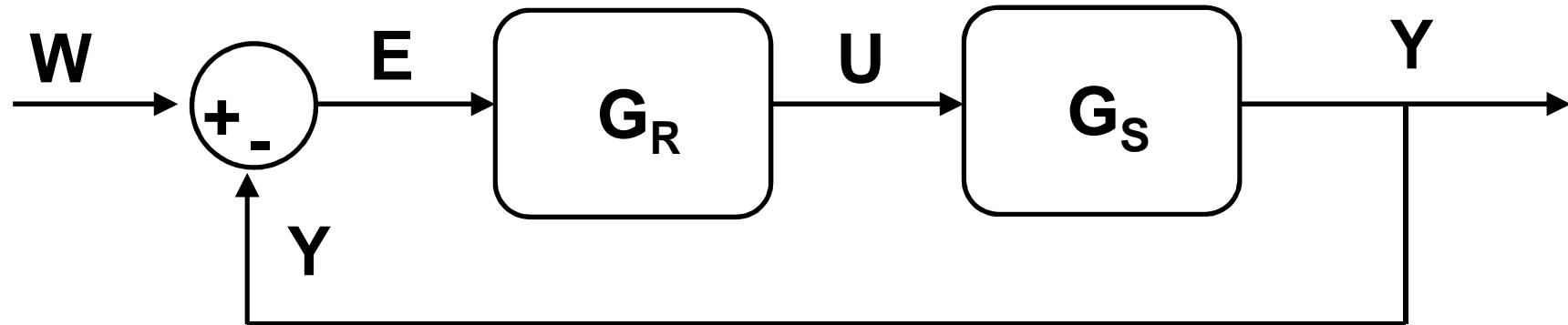
$$Y = G_S U = G_S G_R E = G_S G_R (W - Y)$$

## Prenos URO



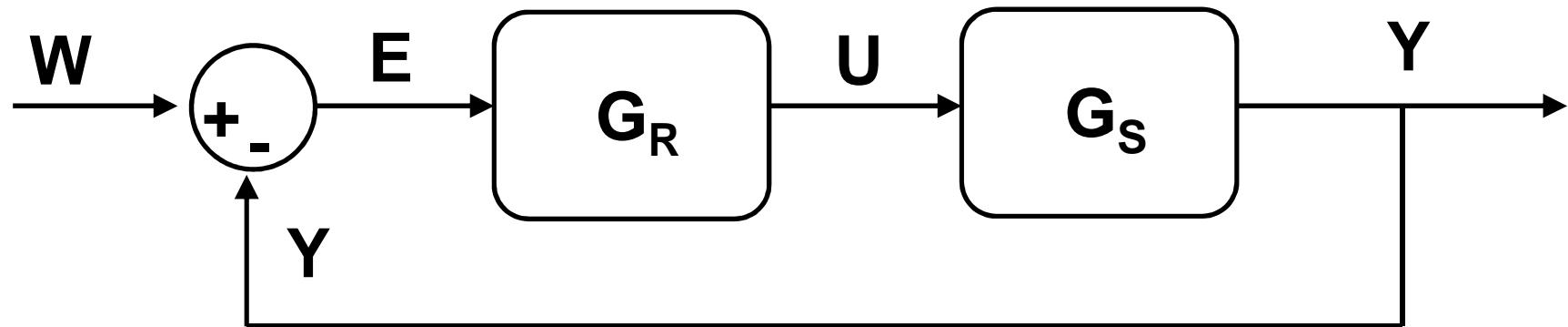
$$\begin{aligned} Y &= G_S U = G_S G_R E = G_S G_R (W - Y) = \\ &= G_S G_R W - G_S G_R Y \end{aligned}$$

# Prenos URO



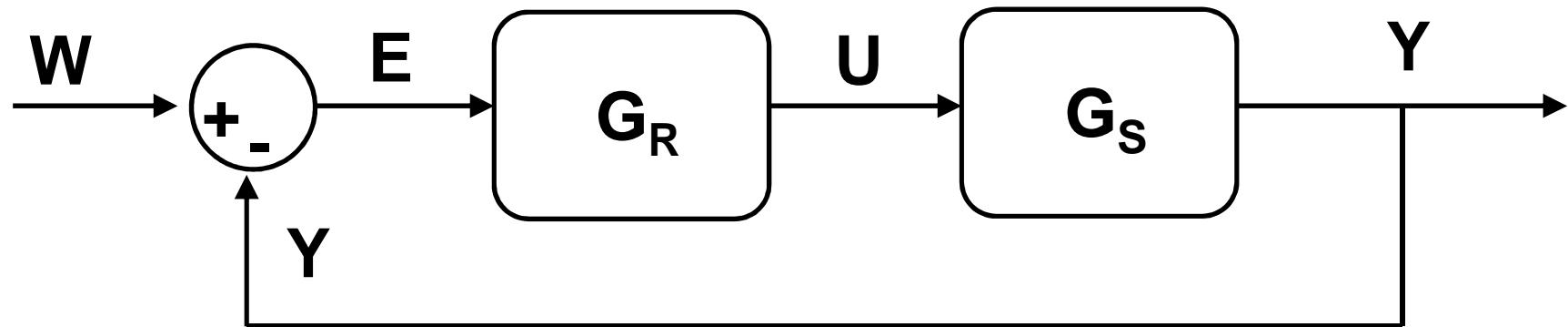
$$Y = G_S G_R W - G_S G_R Y$$

## Prenos URO



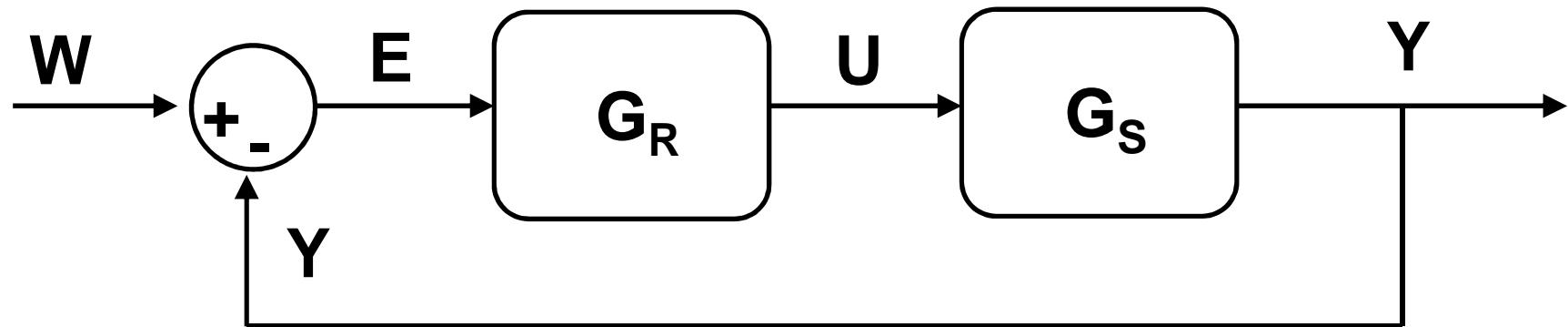
$$Y = G_S G_R W - G_S G_R Y \quad / + G_S G_R Y$$

# Prenos URO



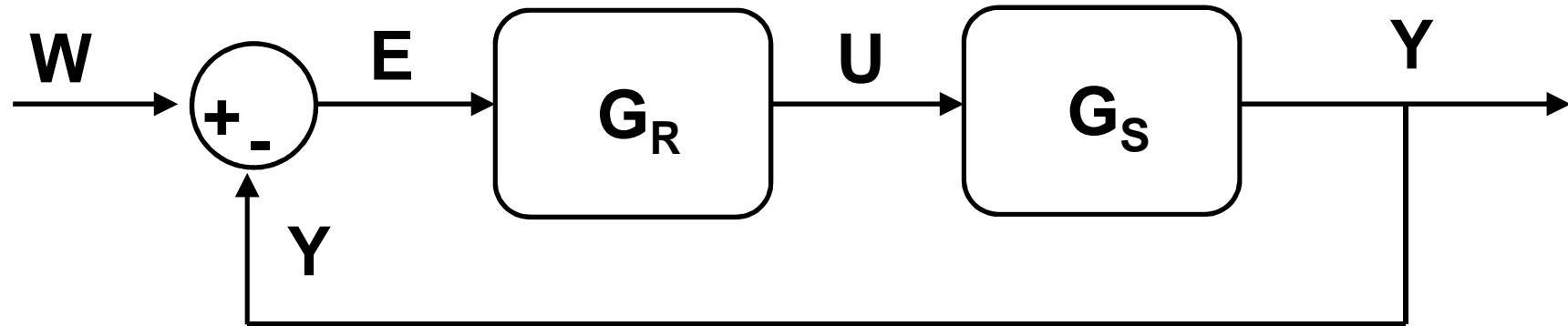
$$Y + G_S G_R Y = G_S G_R W$$

## Prenos URO



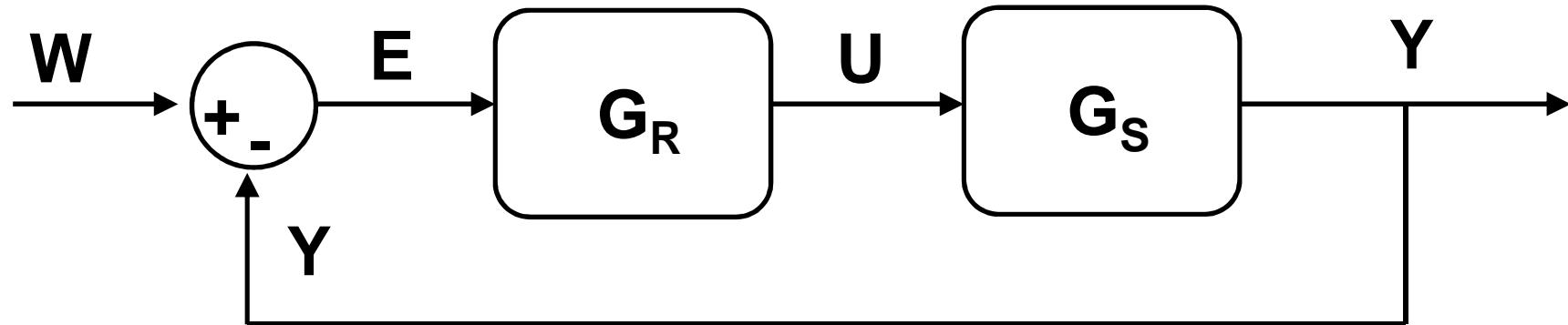
$$Y(1 + G_S G_R) = G_S G_R W$$

# Prenos URO



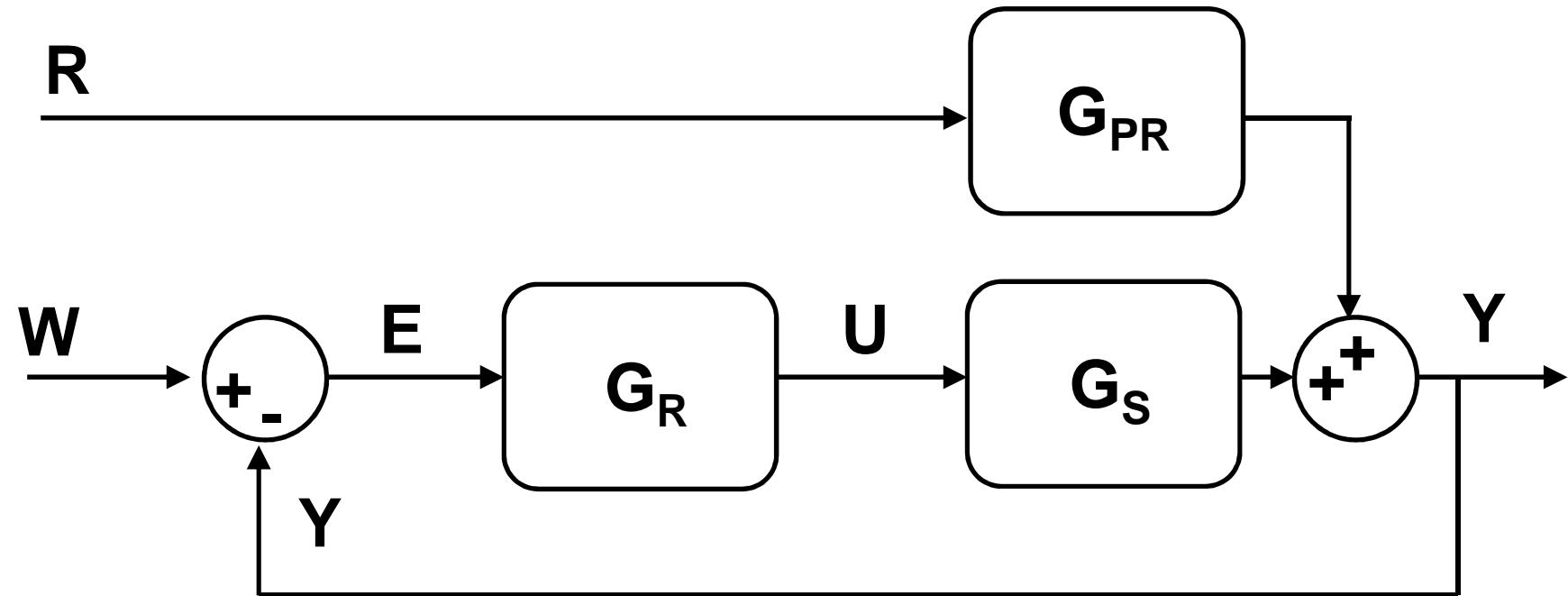
$$Y / W = G_S G_R / (1 + G_S G_R)$$

# Prenos URO

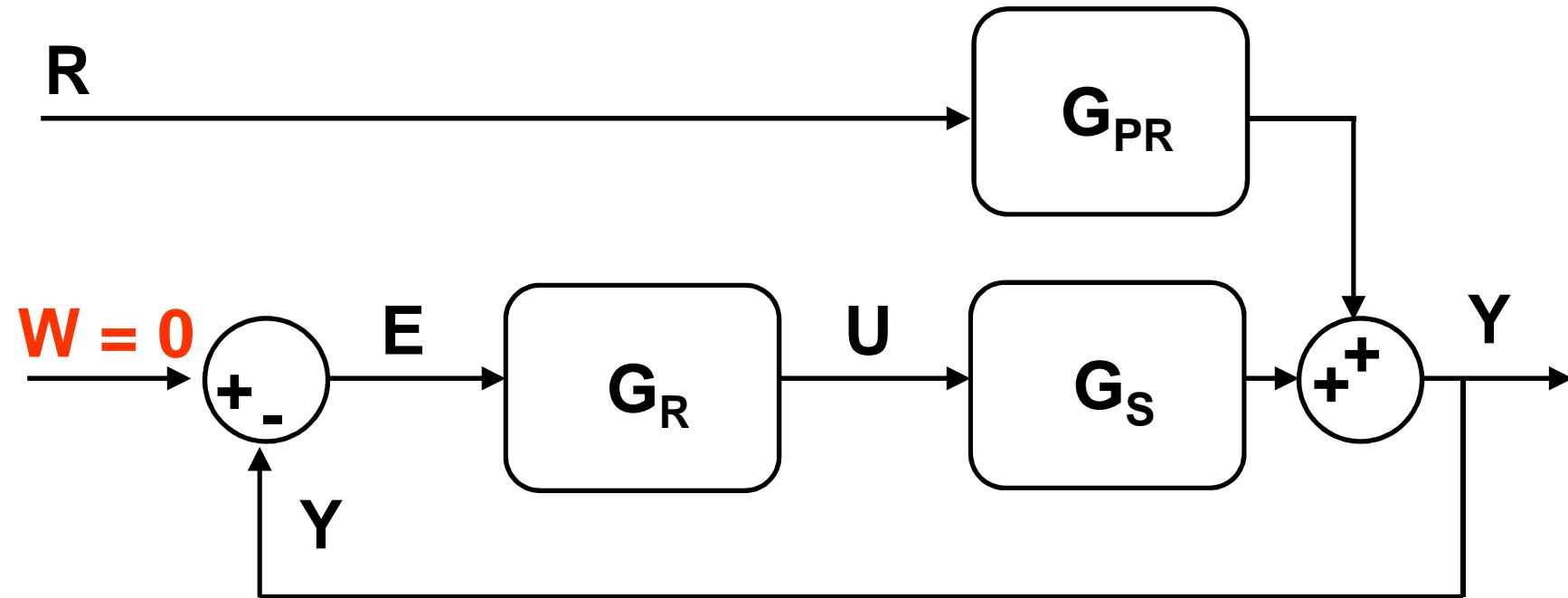


$$G_{URO} = \frac{Y}{W} = \frac{G_R G_S}{1 + G_R G_S}$$

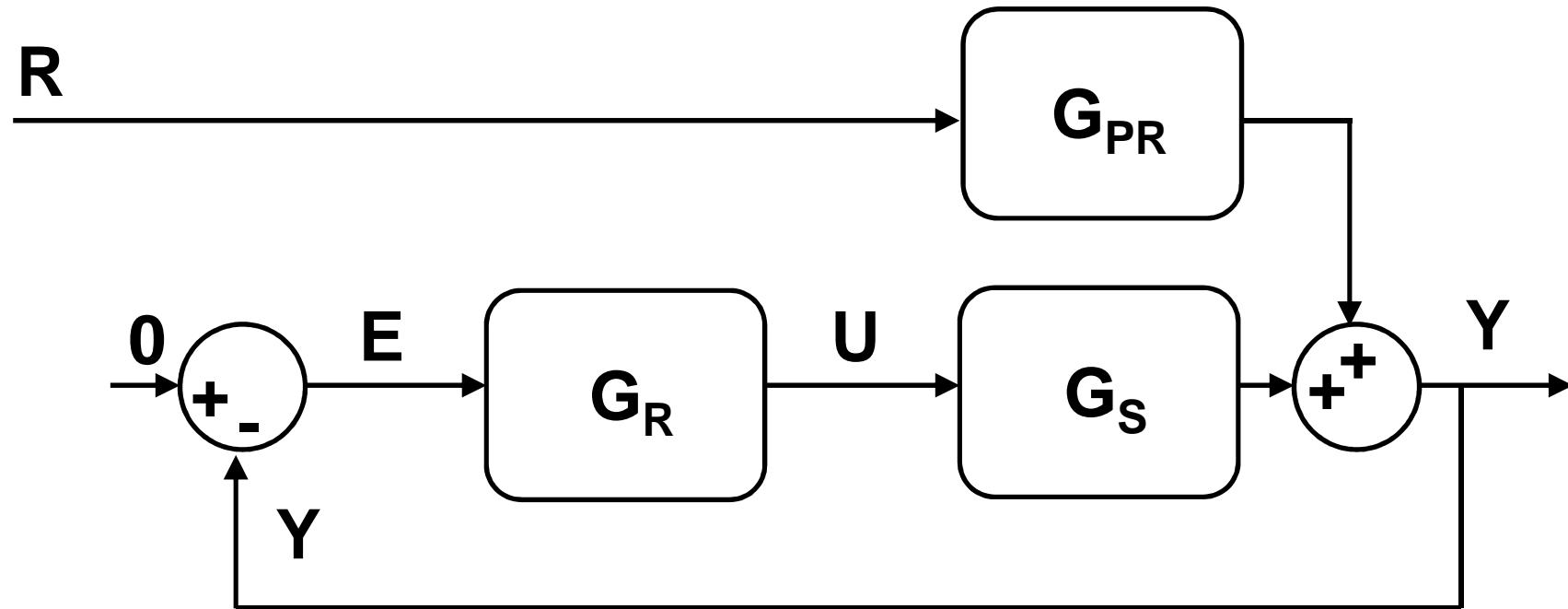
# Prenos URO



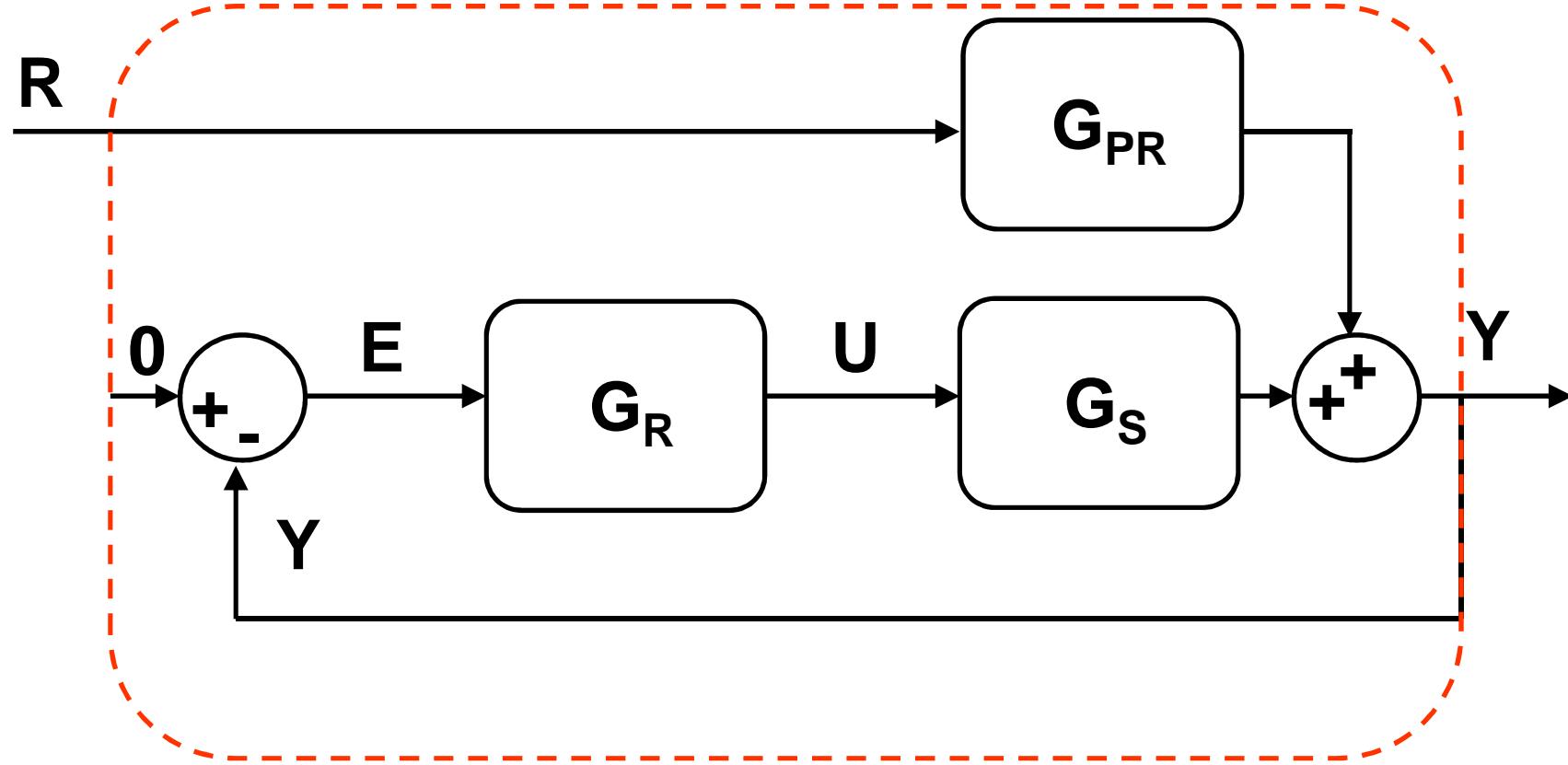
# Prenos URO



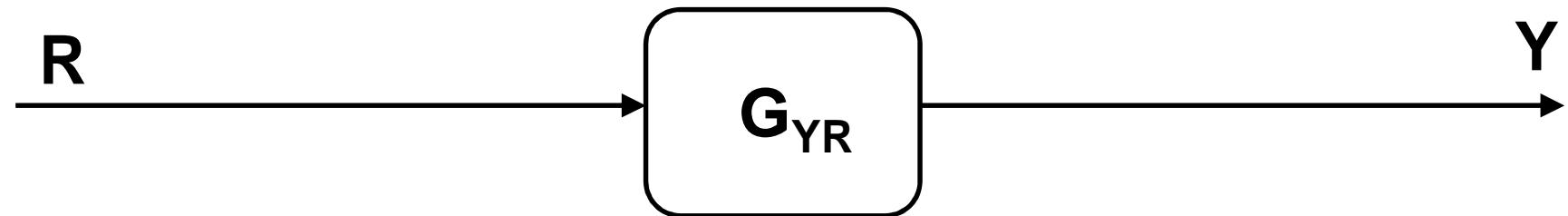
# Prenos URO



# Prenos URO

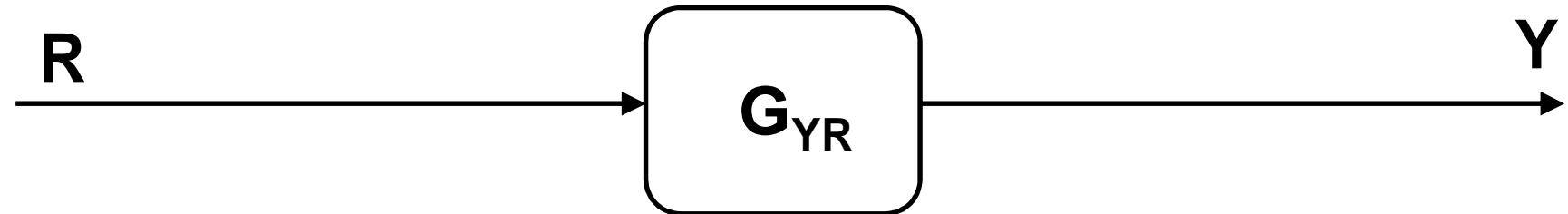


# Prenos URO



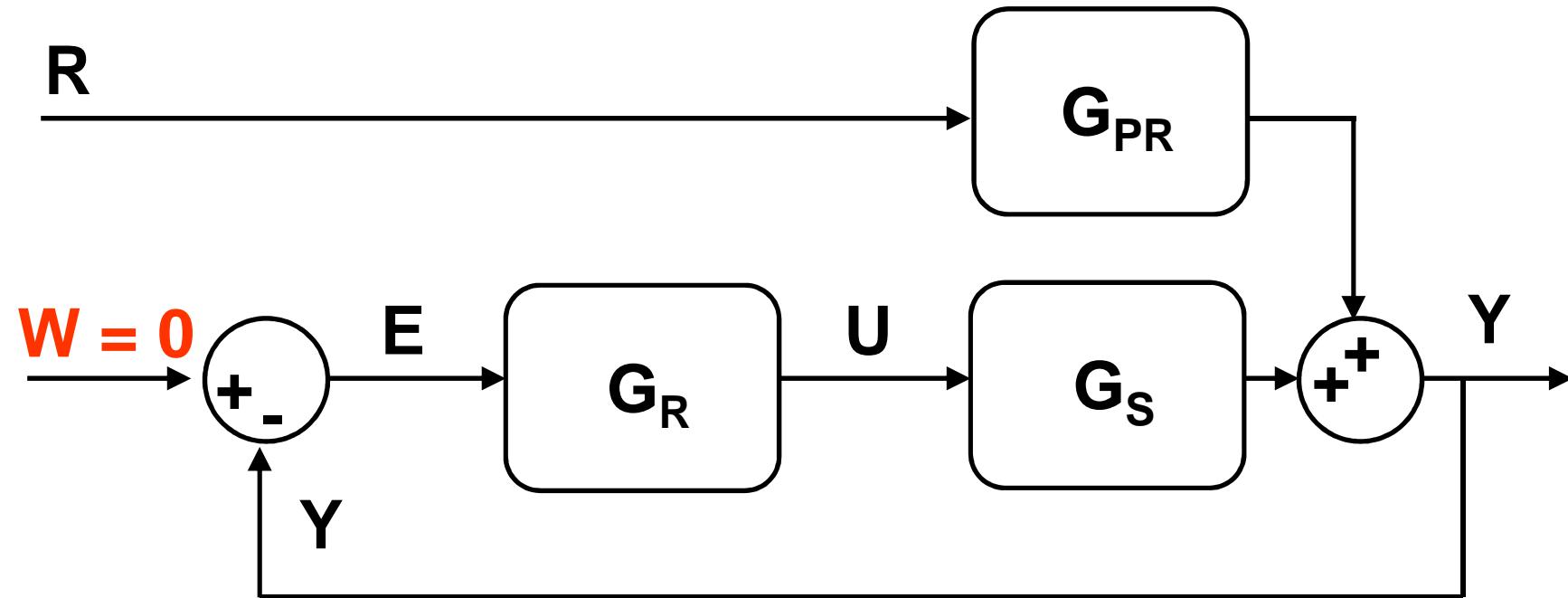
$$Y = G_{YR}R$$

# Prenos URO

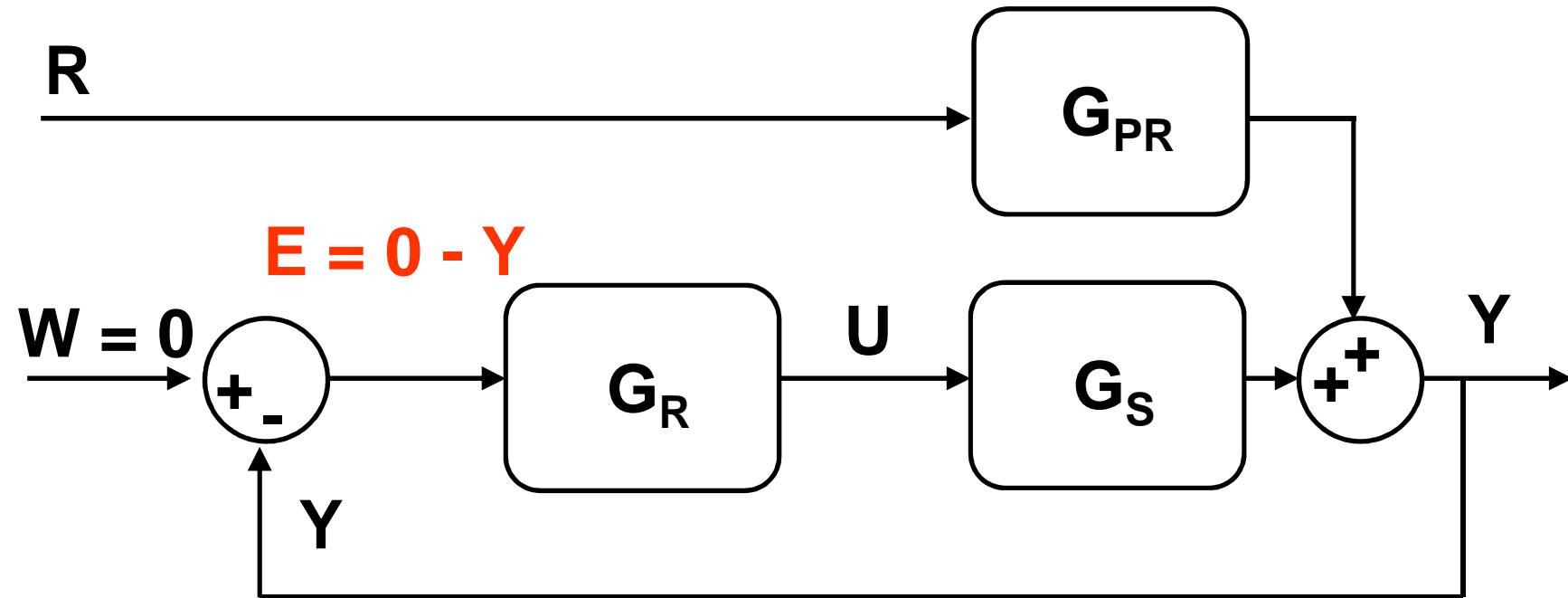


$$Y = G_{YR} ? R$$

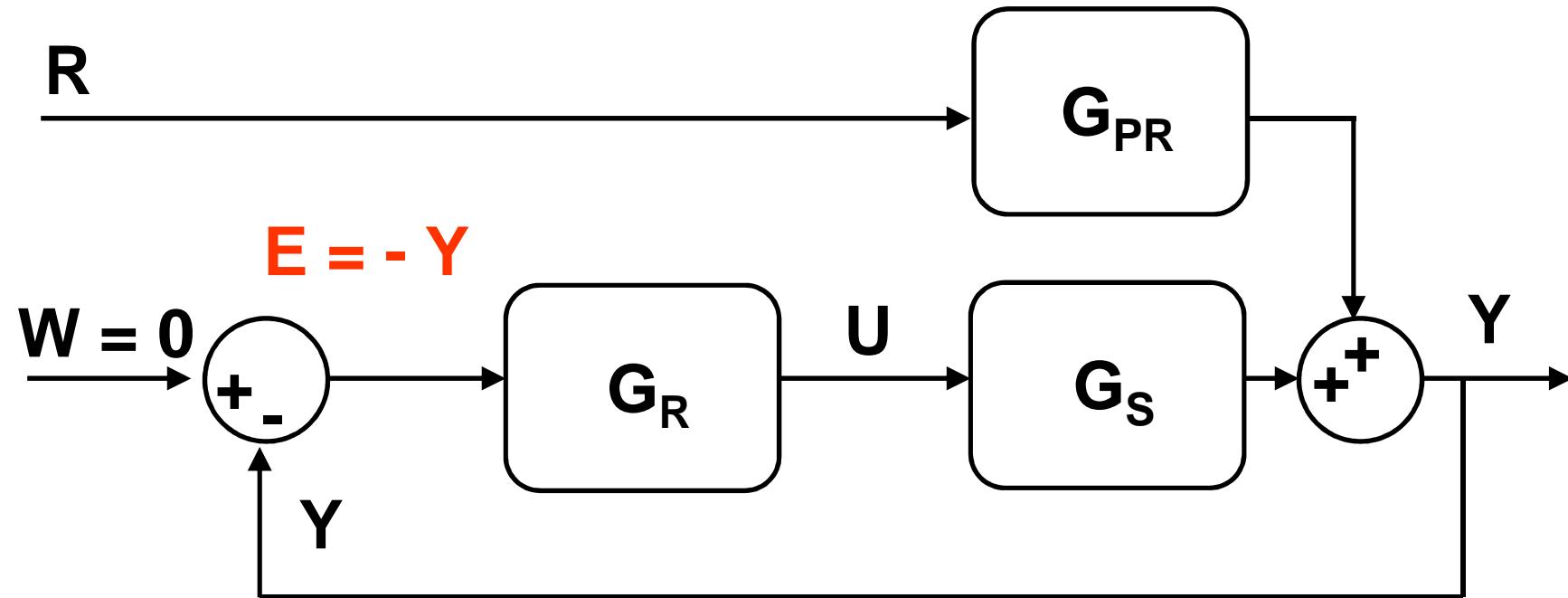
# Prenos URO



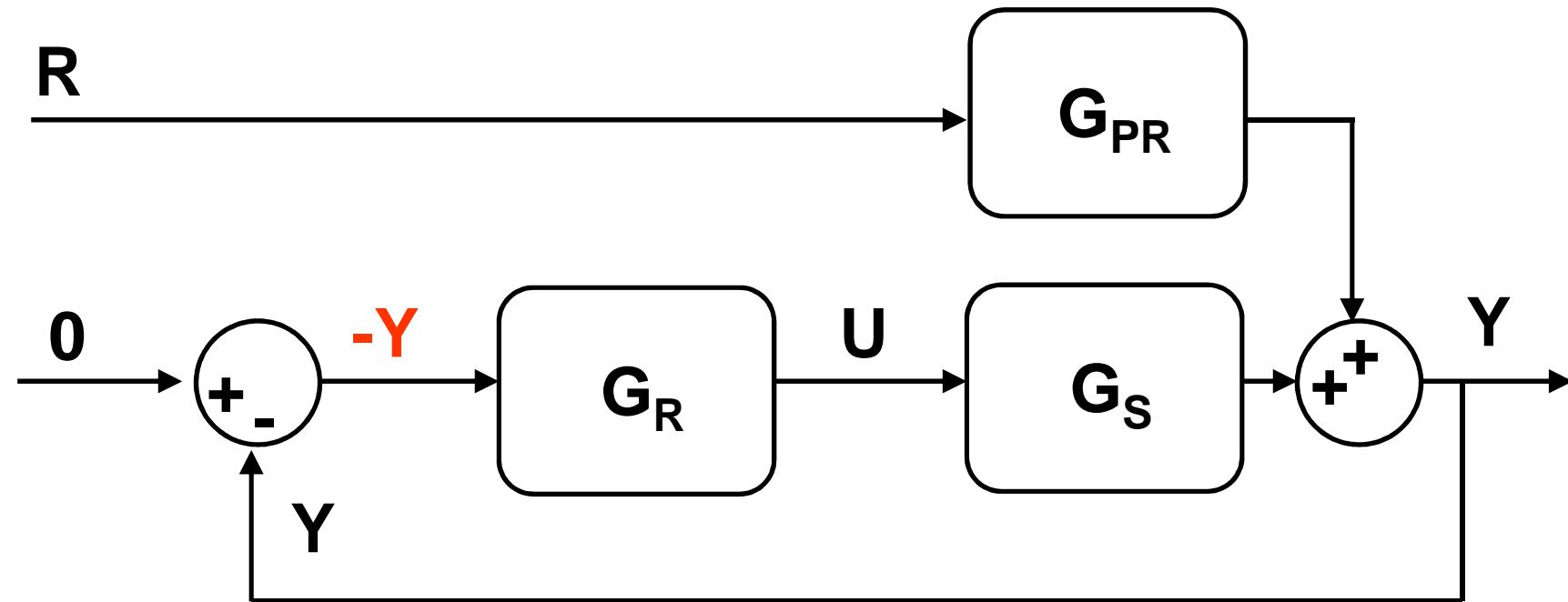
# Prenos URO



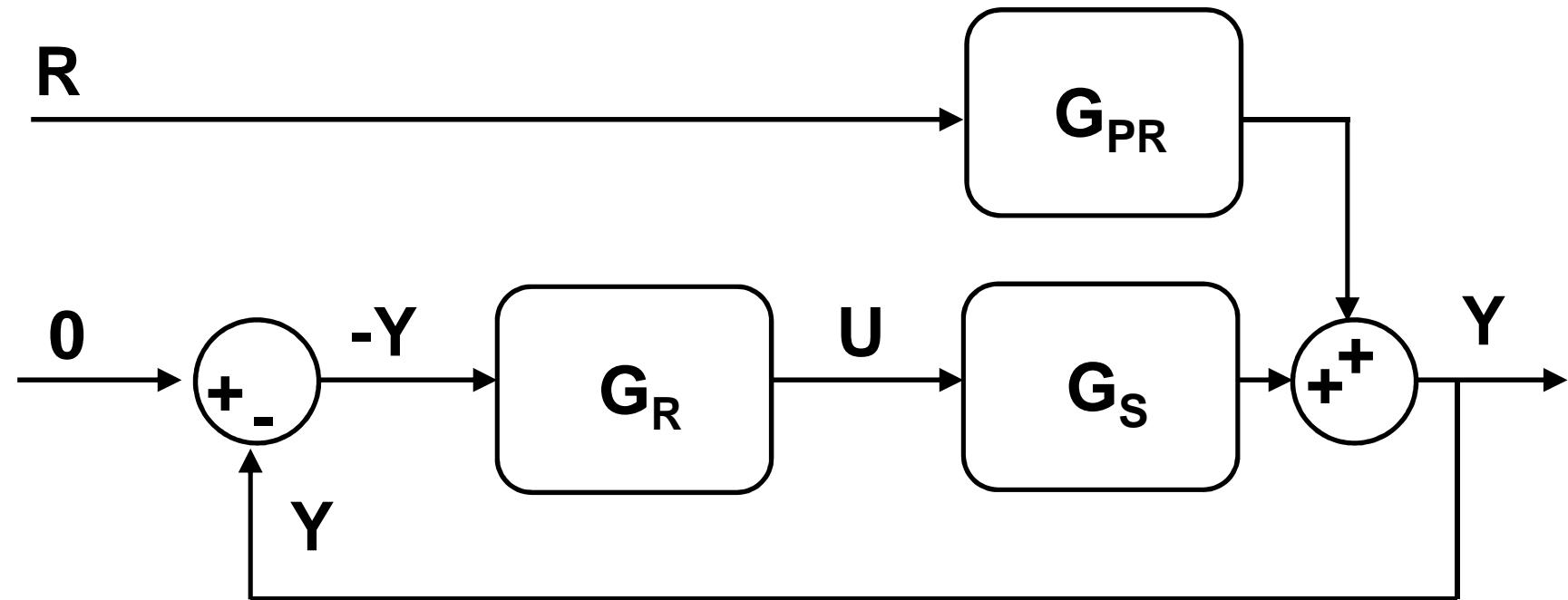
# Prenos URO



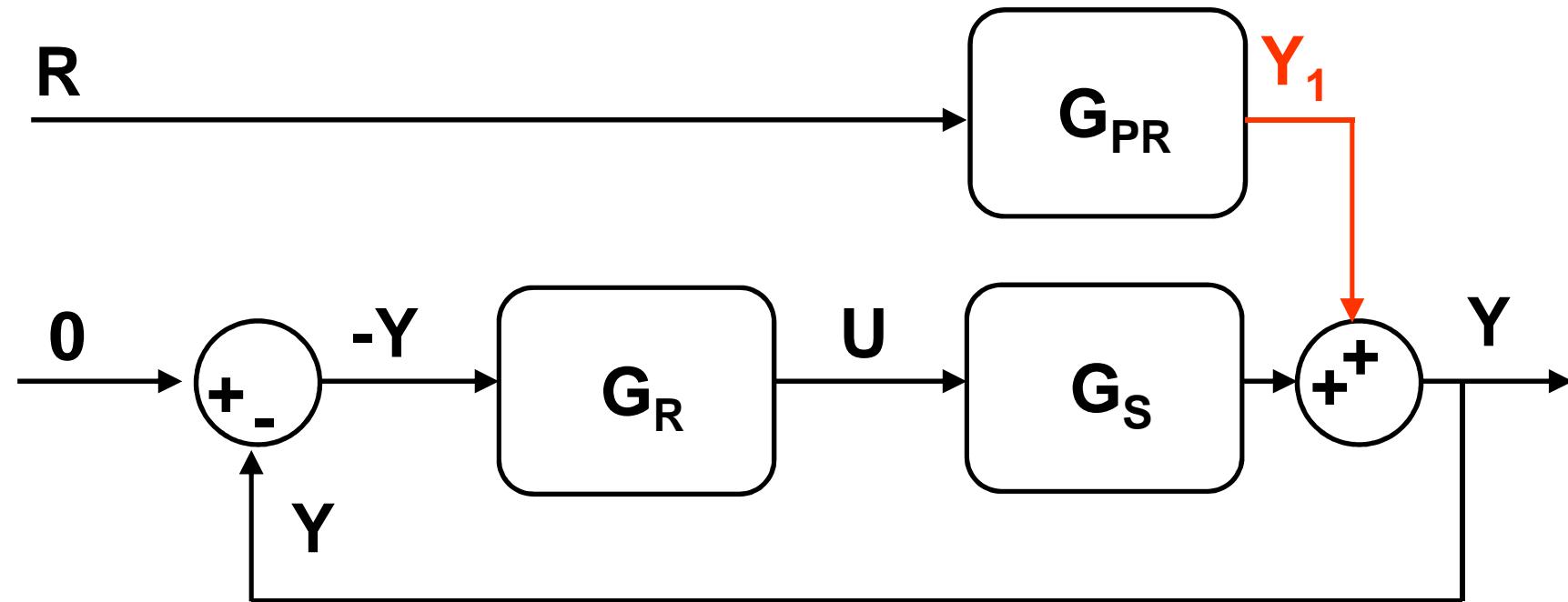
# Prenos URO



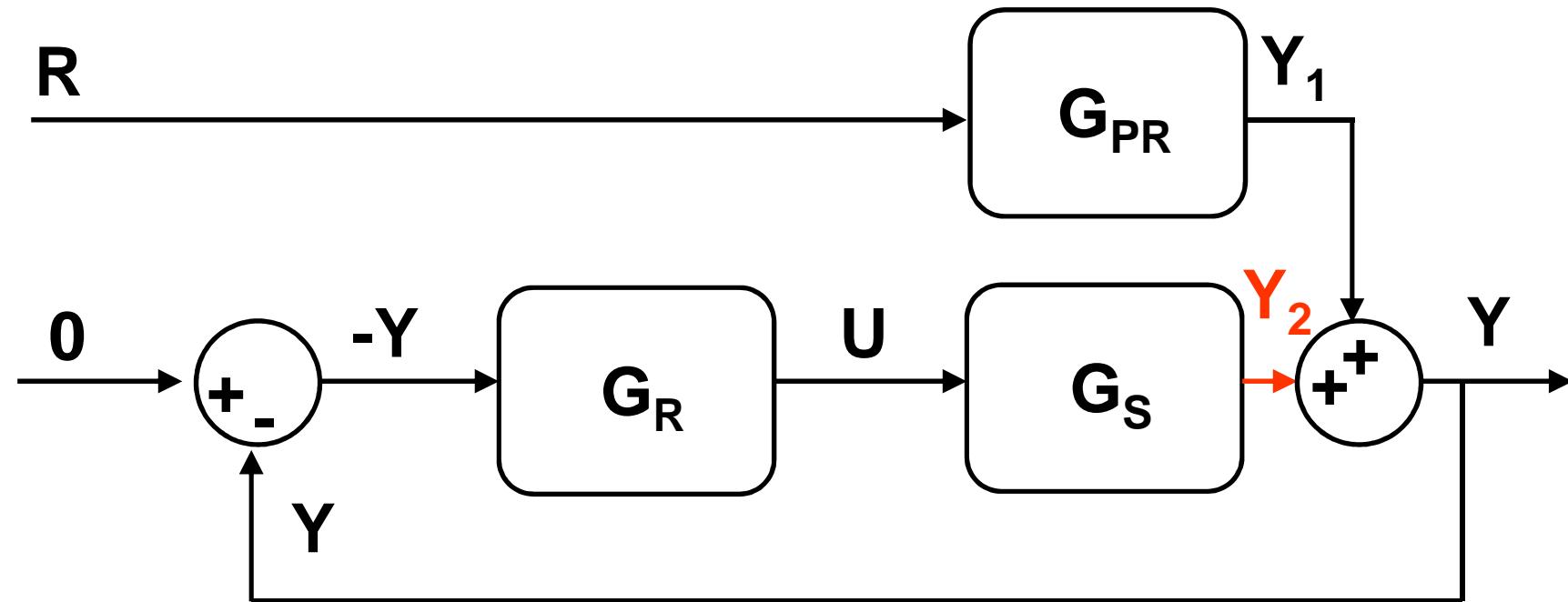
# Prenos URO



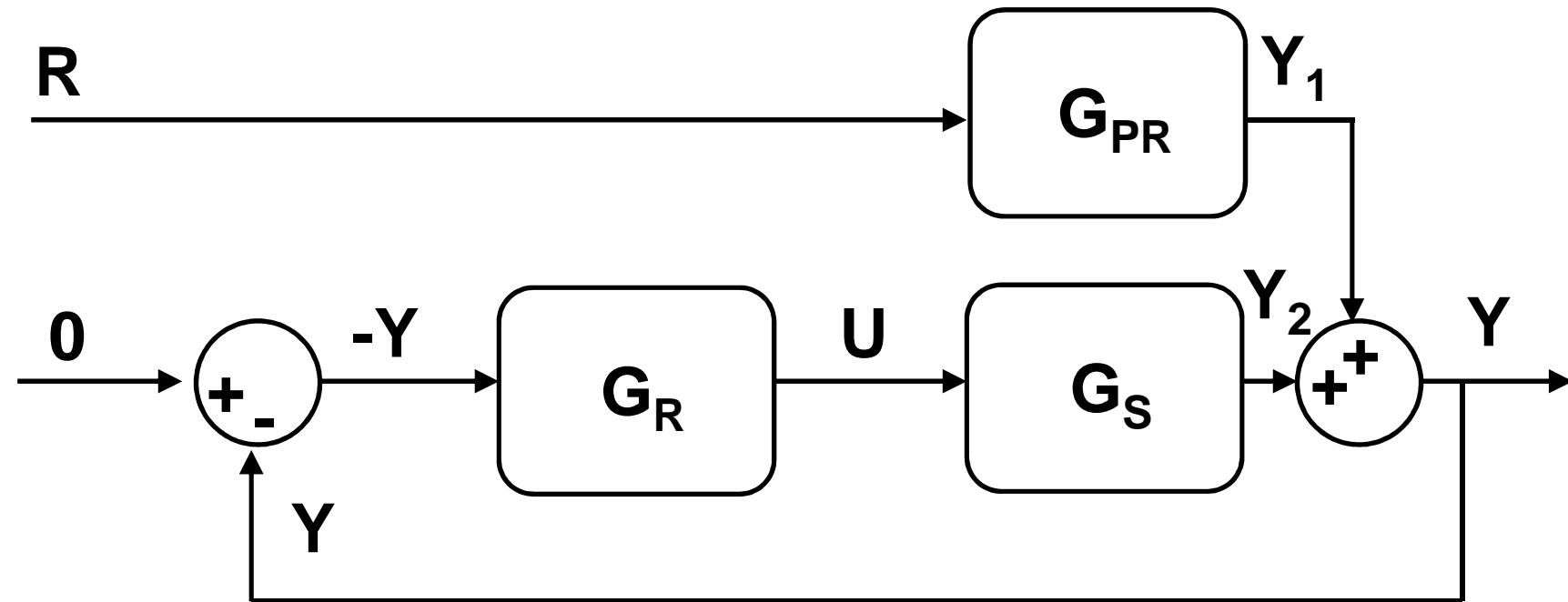
# Prenos URO



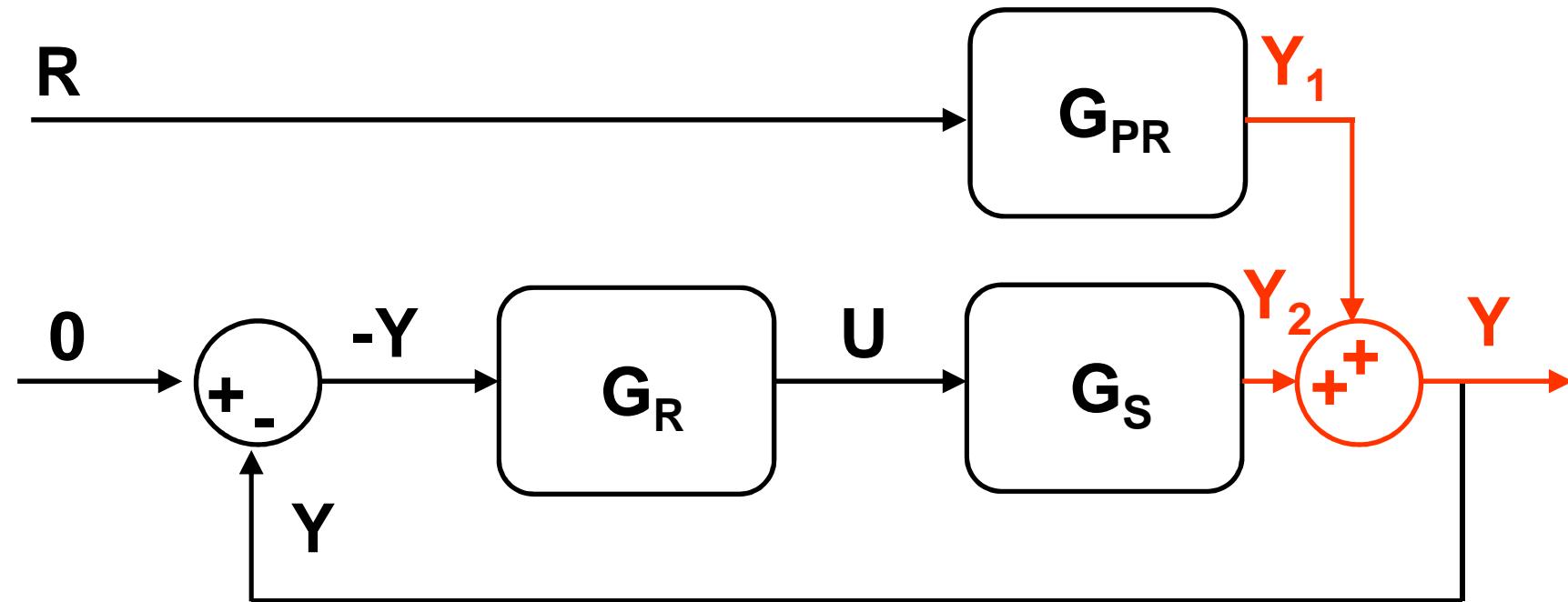
# Prenos URO



# Prenos URO

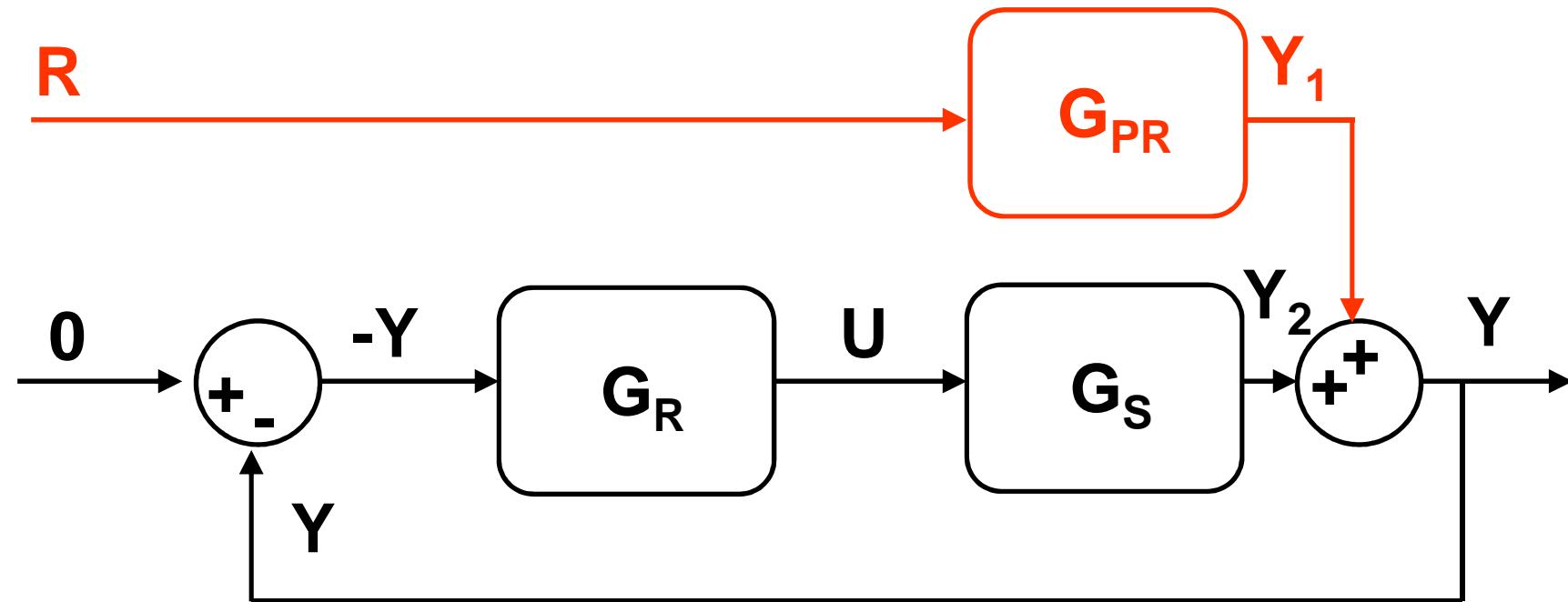


# Prenos URO



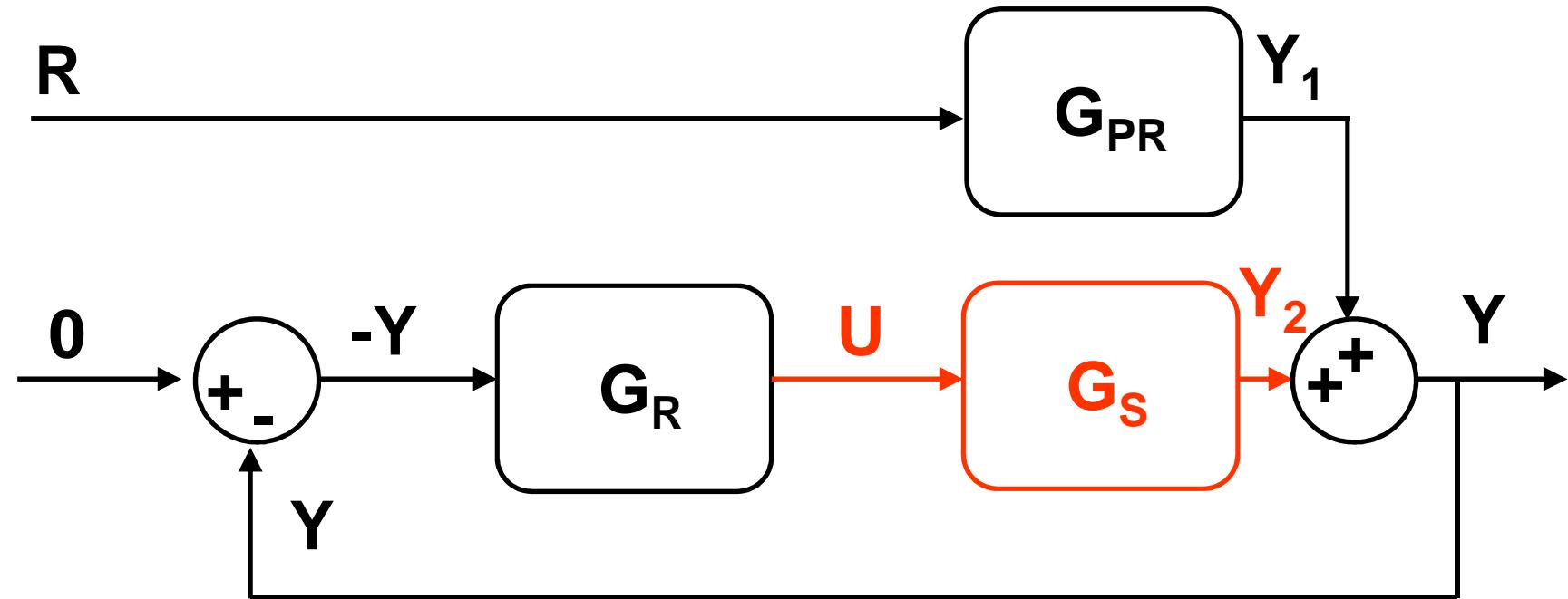
$$Y = Y_1 + Y_2$$

## Prenos URO



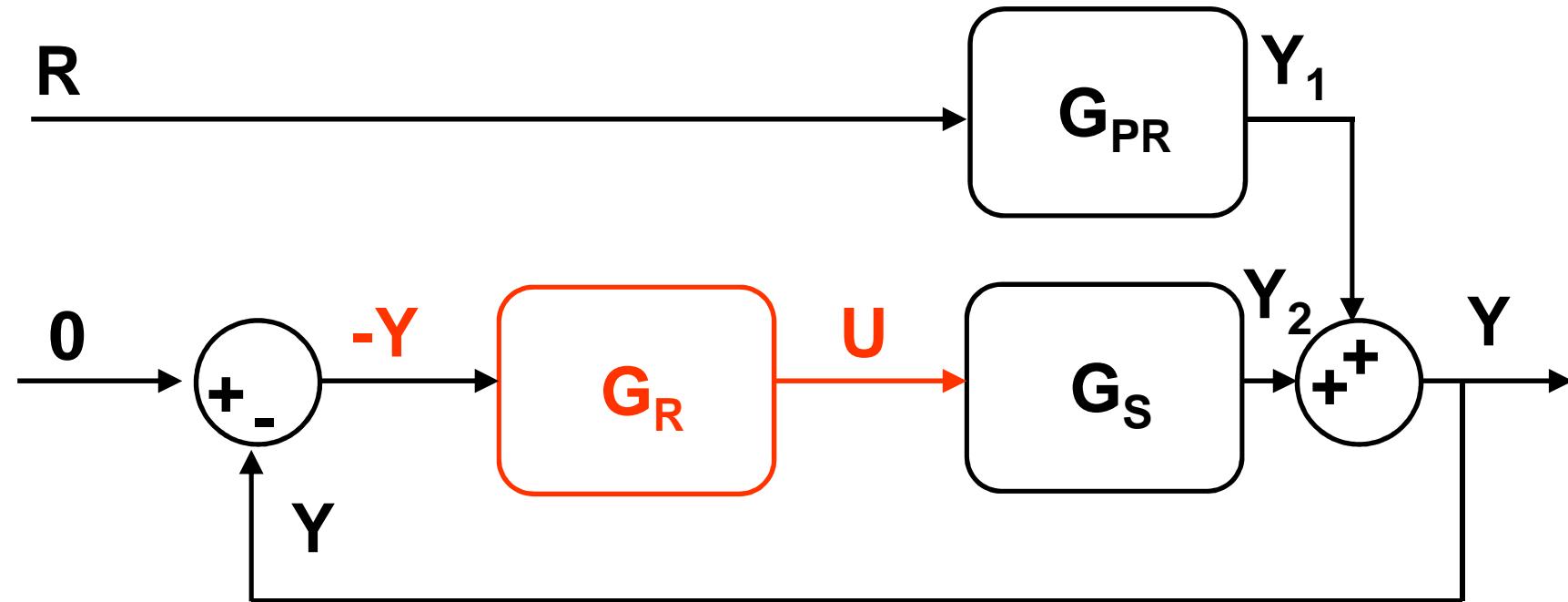
$$Y = Y_1 + Y_2 = G_{PR}R + Y_2$$

## Prenos URO



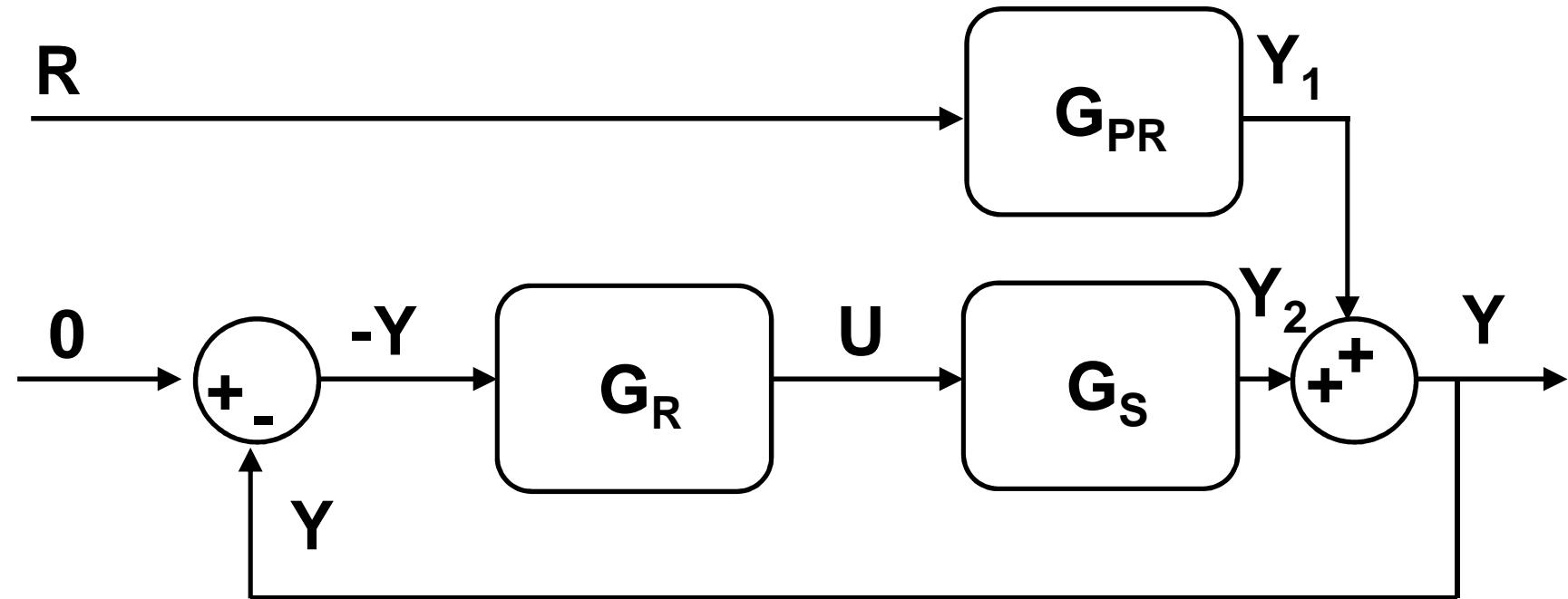
$$Y = Y_1 + Y_2 = G_{PR}R + G_S U$$

## Prenos URO



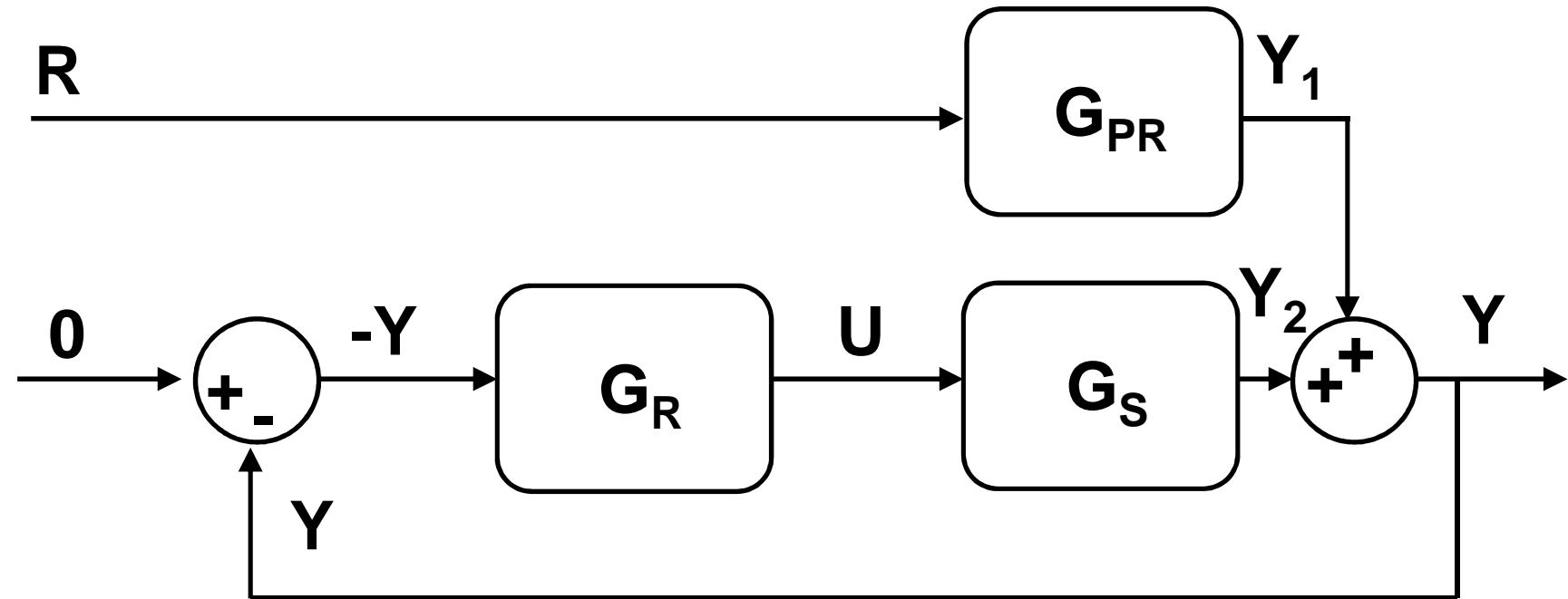
$$Y = Y_1 + Y_2 = G_{PR}R + G_S U = G_{PR}R - G_S G_R Y$$

## Prenos URO



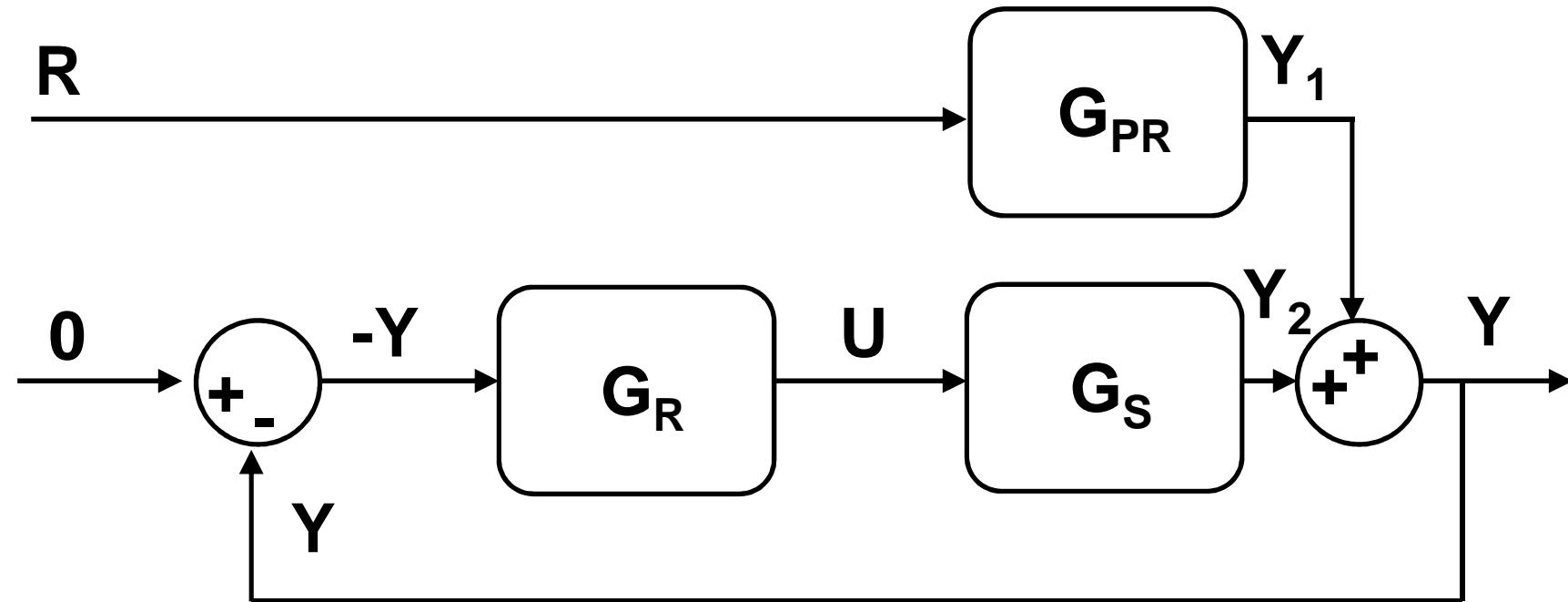
$$Y = Y_1 + Y_2 = G_{PR}R + G_SU = G_{PR}R - G_SG_RY$$

## Prenos URO



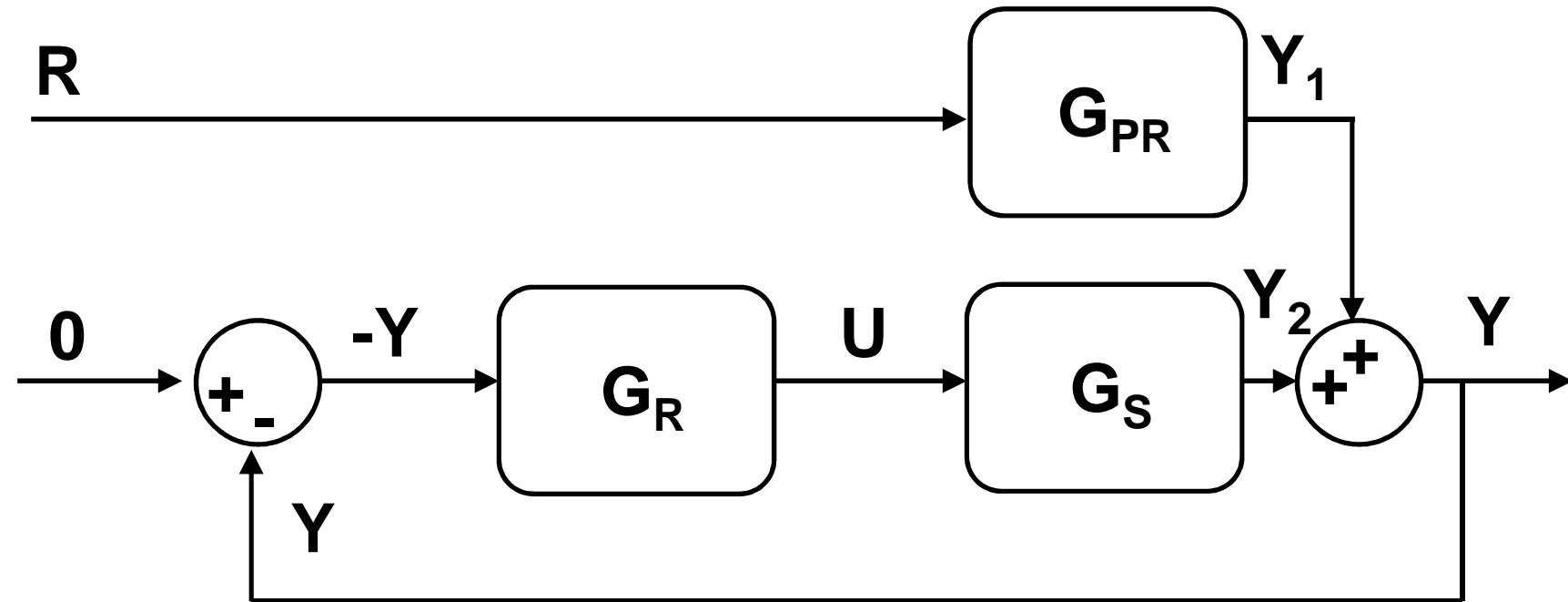
$$Y = G_{PR}R - G_S G_R Y$$

## Prenos URO



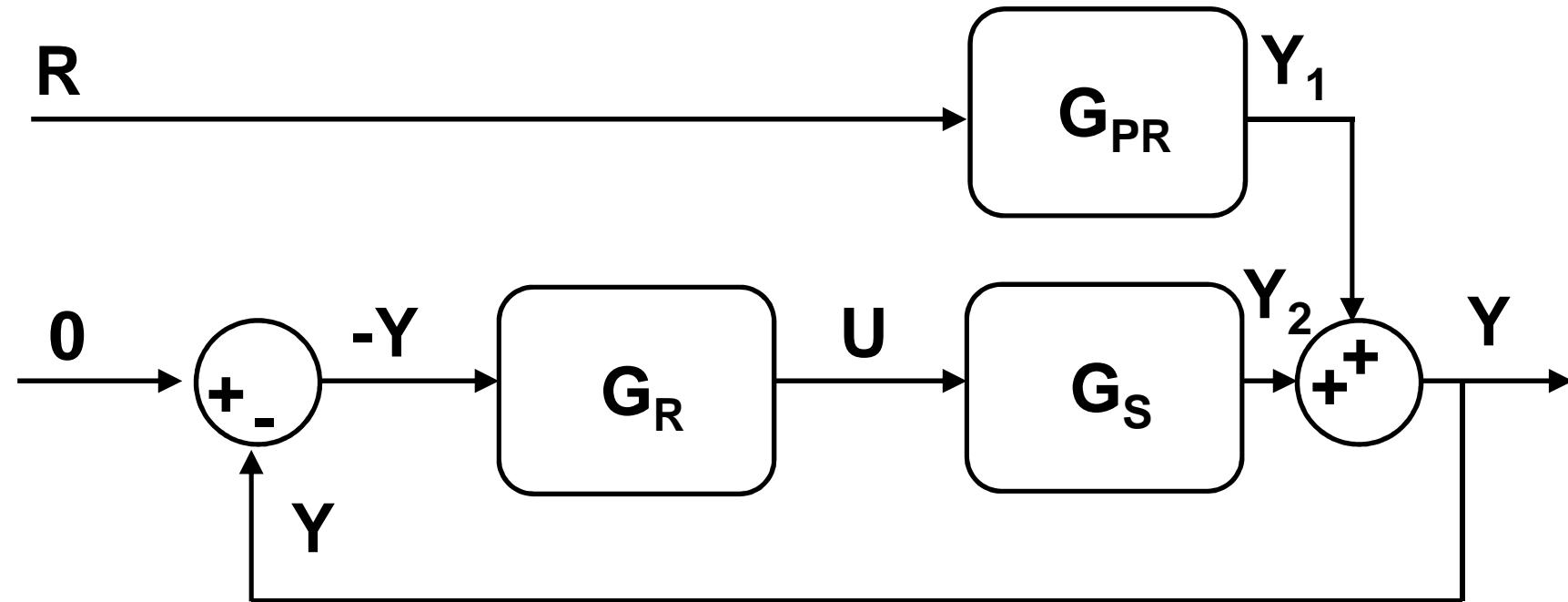
$$Y = G_{PR}R - G_S G_R Y \quad / + G_S G_R Y$$

## Prenos URO



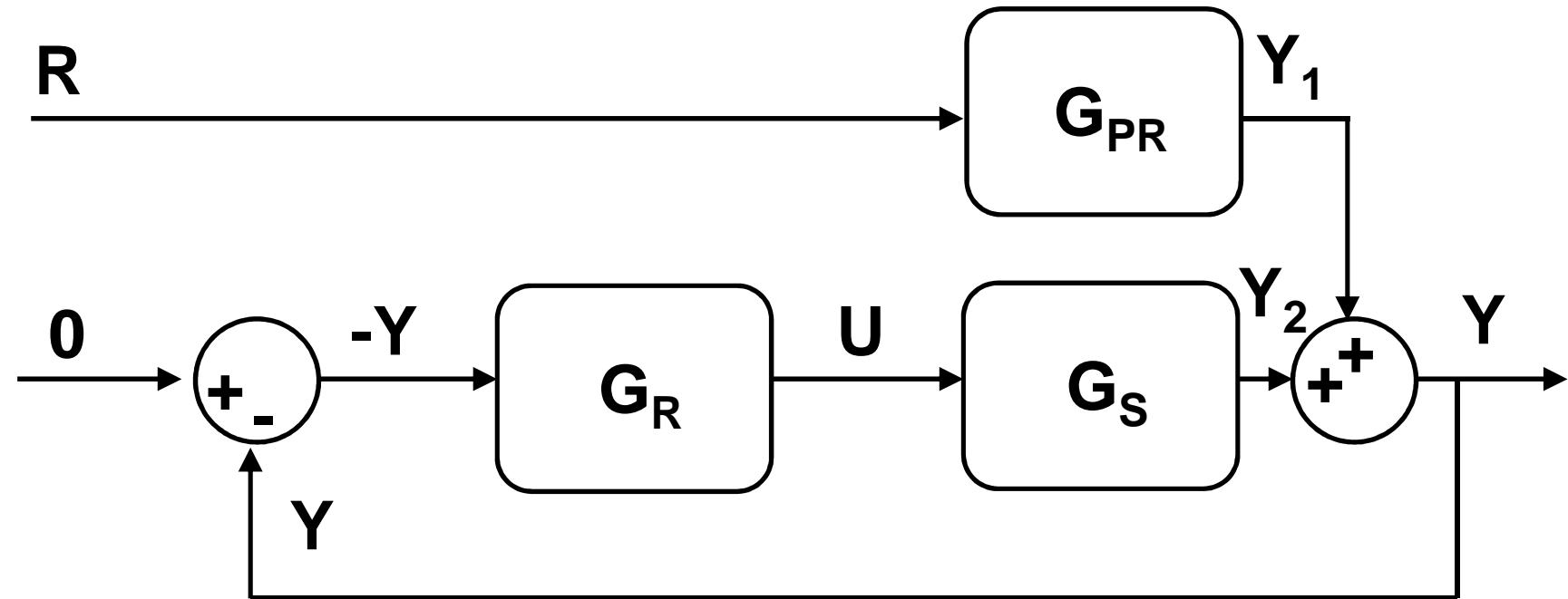
$$Y + G_S G_R Y = G_{PR} R$$

## Prenos URO



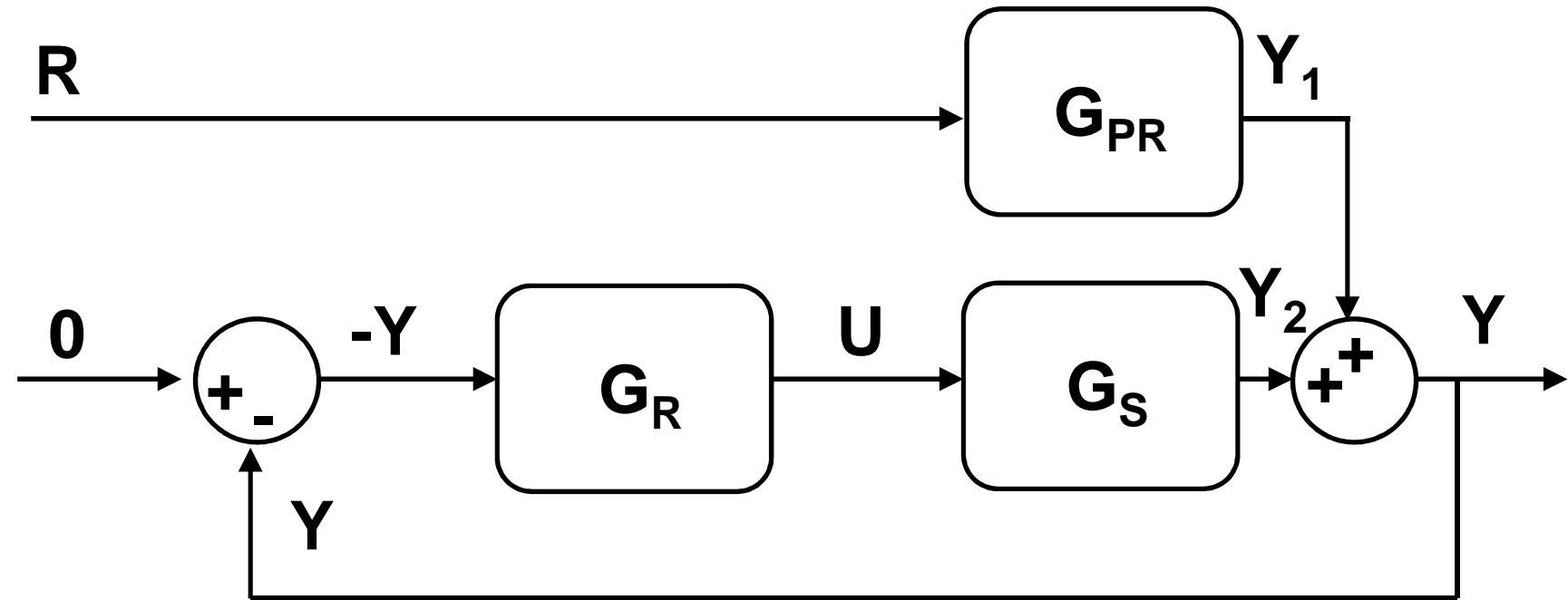
$$Y(1 + G_S G_R) = G_{PR} R$$

## Prenos URO



$$Y / R = G_{PR} / (1 + G_S G_R)$$

## Prenos URO

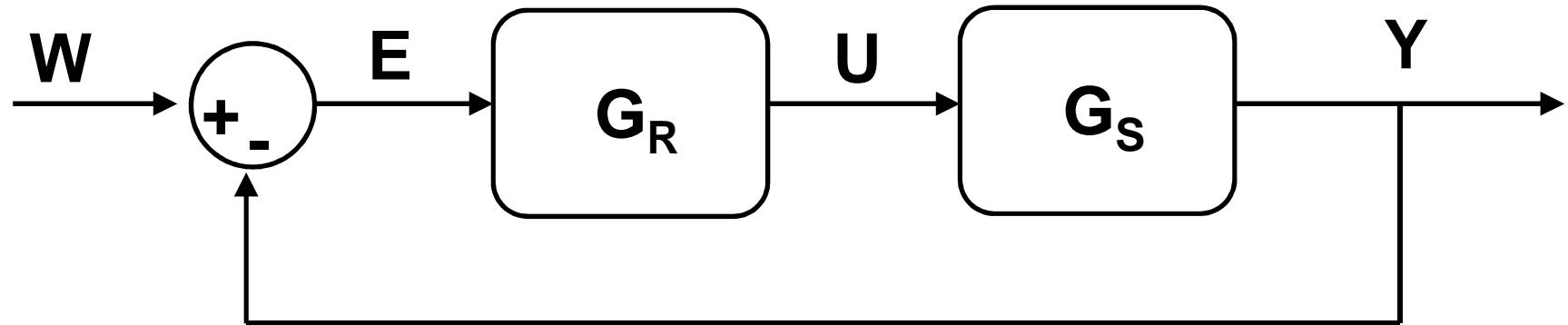


$$G_{YR} = \frac{Y}{R} = \frac{G_{PR}}{1 + G_R G_S}$$

## 7. Zadanie z LCRP – teoretická časť

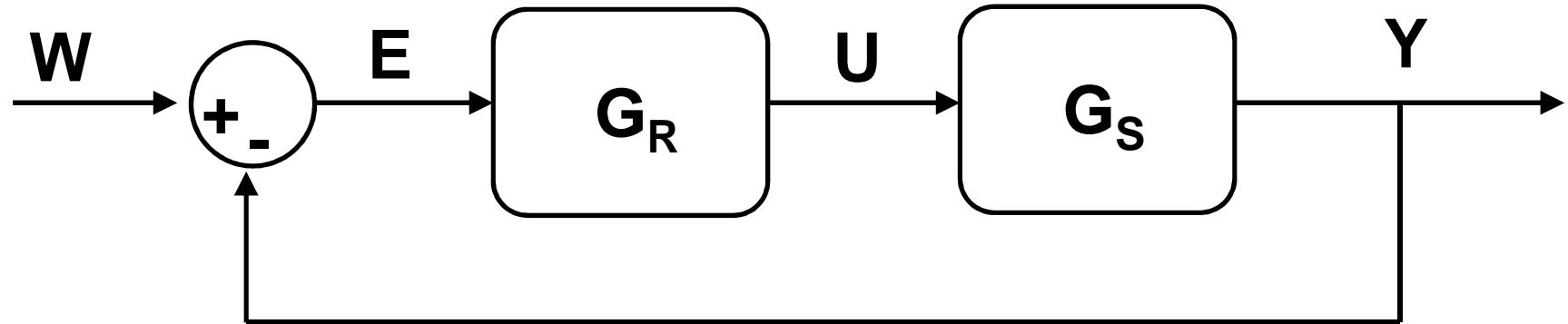
- **URO**
- prenos URO
- **CHR URO**
- **zákon riadenia**
- **Routhovo-Schurovo kritérium stability**

# CHR URO



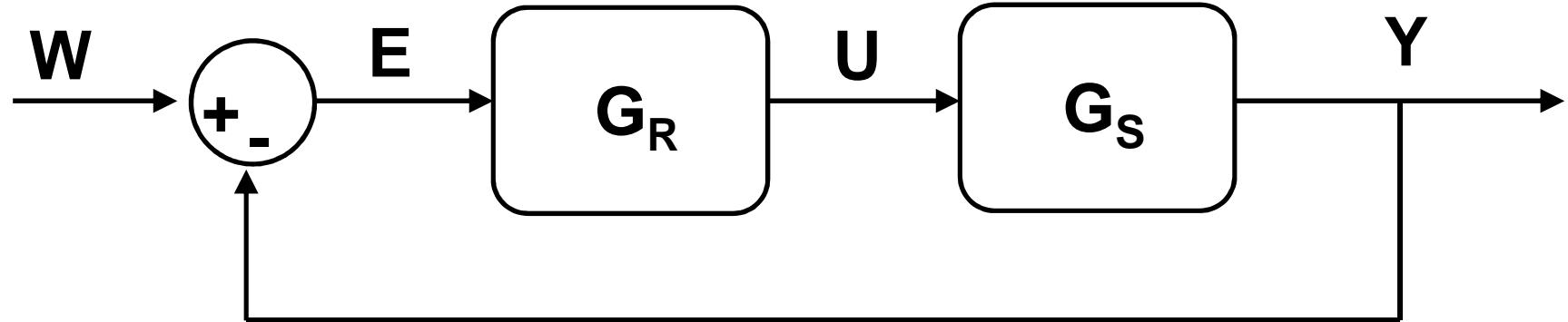
$$G_{URO} = \frac{G_R G_S}{1 + G_R G_S}$$

# CHR URO



$$G_{URO} = \frac{G_R G_S}{1 + G_R G_S} \longrightarrow 1 + G_R G_S = 0$$

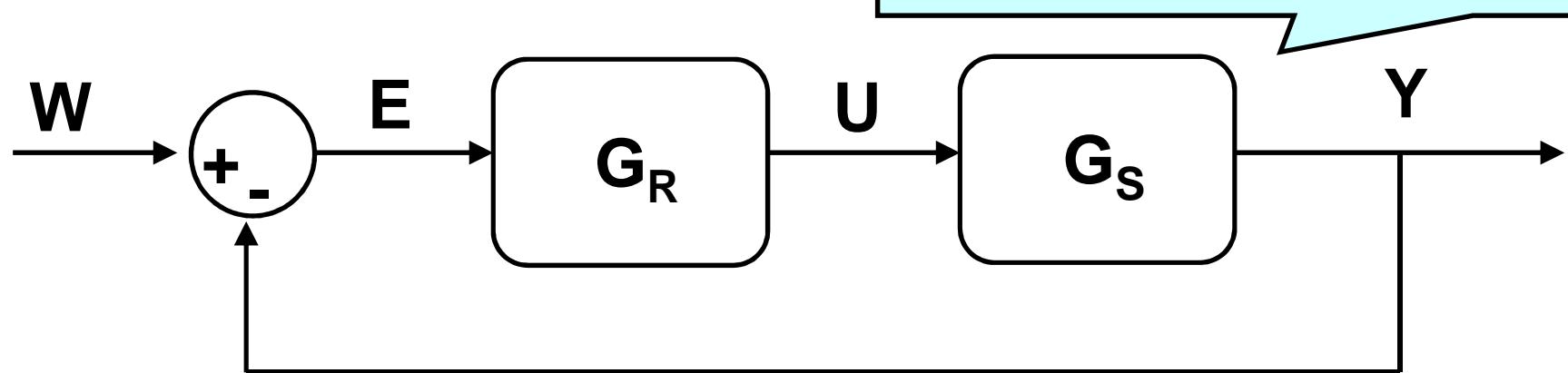
# CHR URO



$$G_{URO} = \frac{G_R G_S}{1 + G_R G_S} \longrightarrow 1 + G_R G_S = 0$$

CHR URO

URO je stabilný, ak  
všetky korene CHR  
URO majú zápornú  
reálnu časť

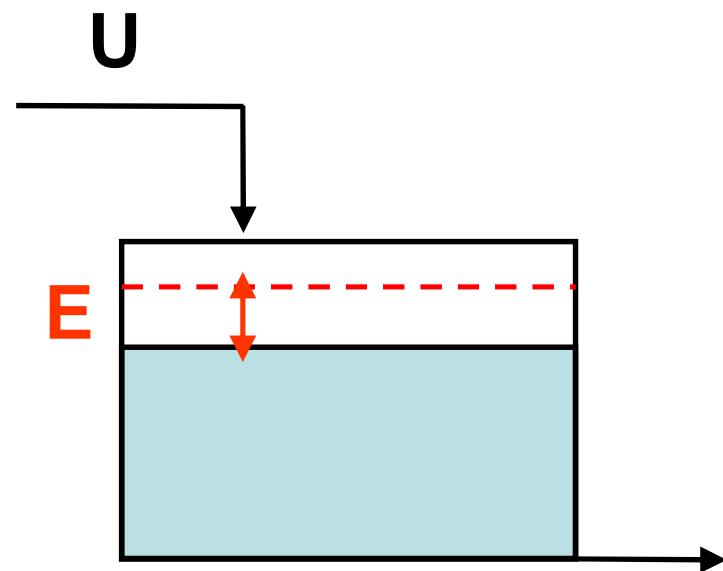


$$G_{URO} = \frac{G_R G_S}{1 + G_R G_S} \longrightarrow 1 + G_R G_S = 0$$

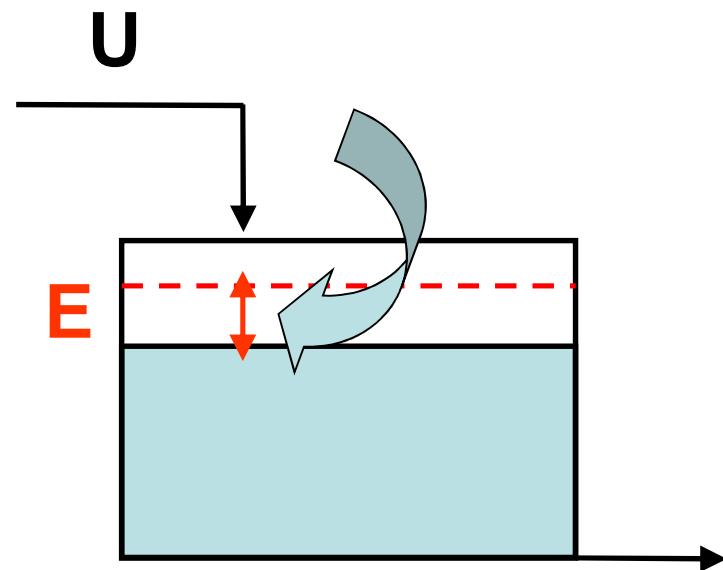
## 7. Zadanie z LCRP – teoretická časť

- URO
- prenos URO
- CHR URO
- **zákon riadenia**
- **Routhovo-Schurovo kritérium stability**

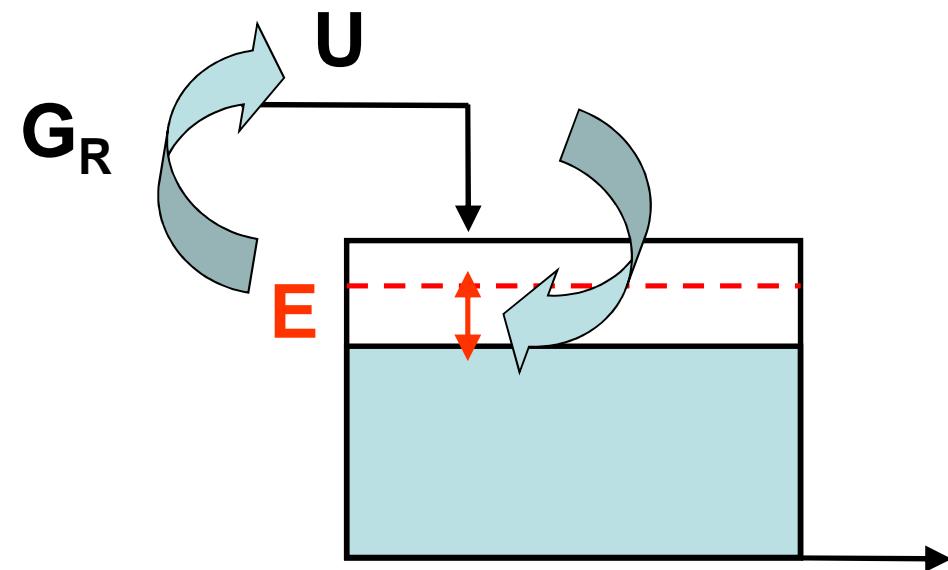
# Zákon riadenia



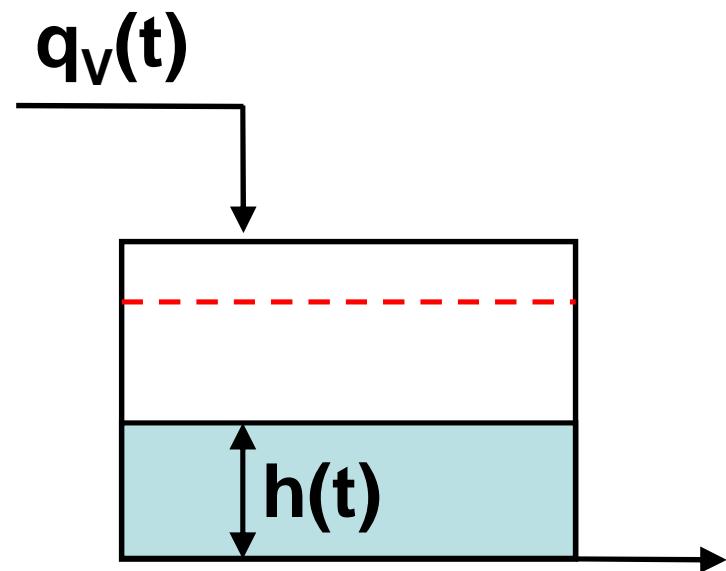
# Zákon riadenia



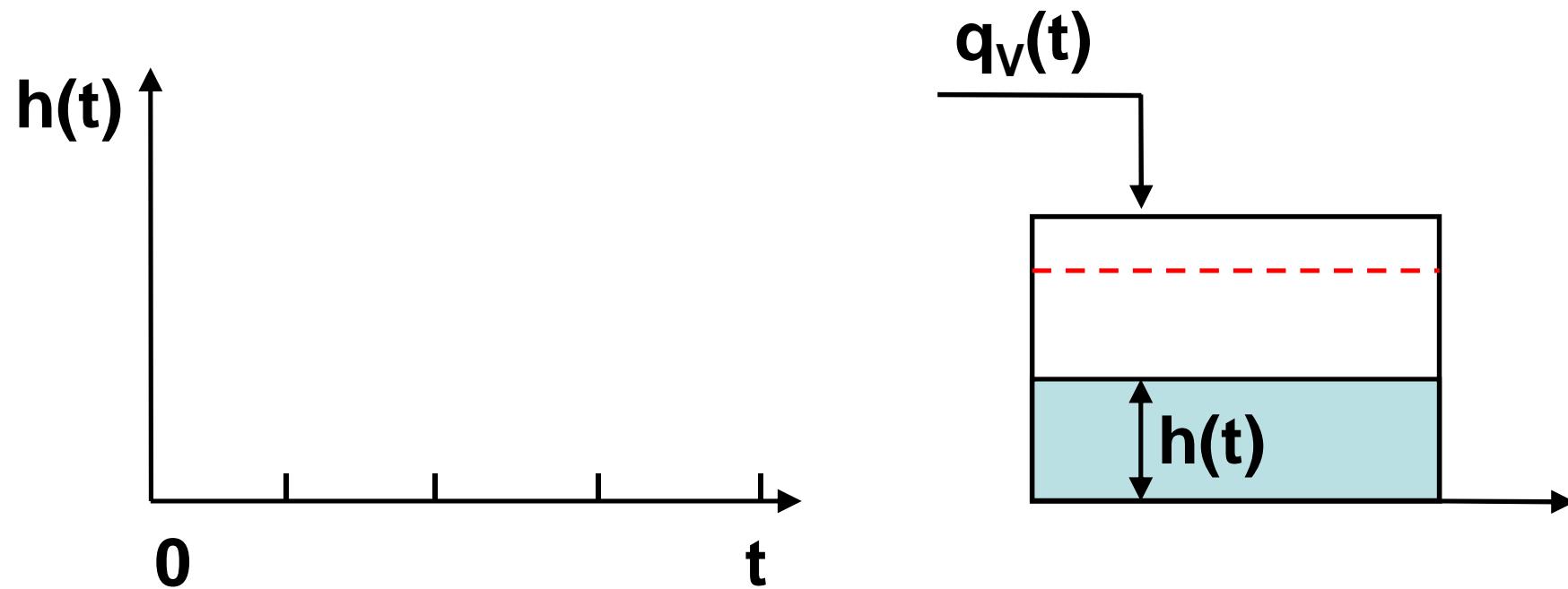
# Zákon riadenia



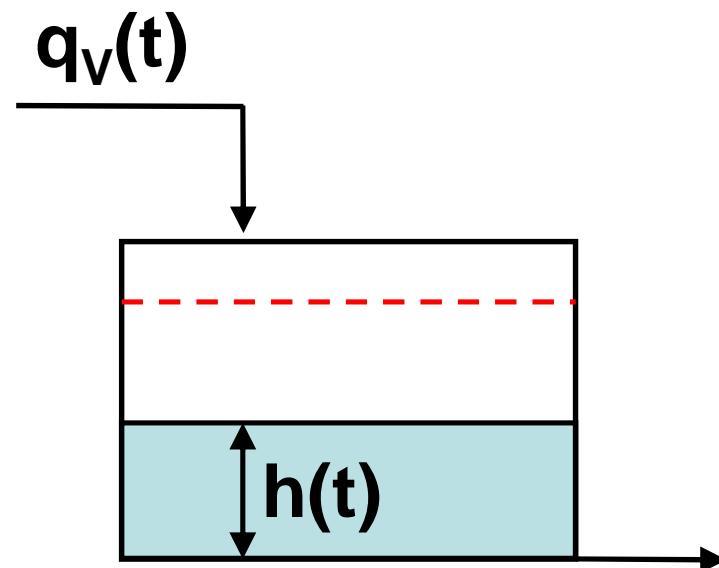
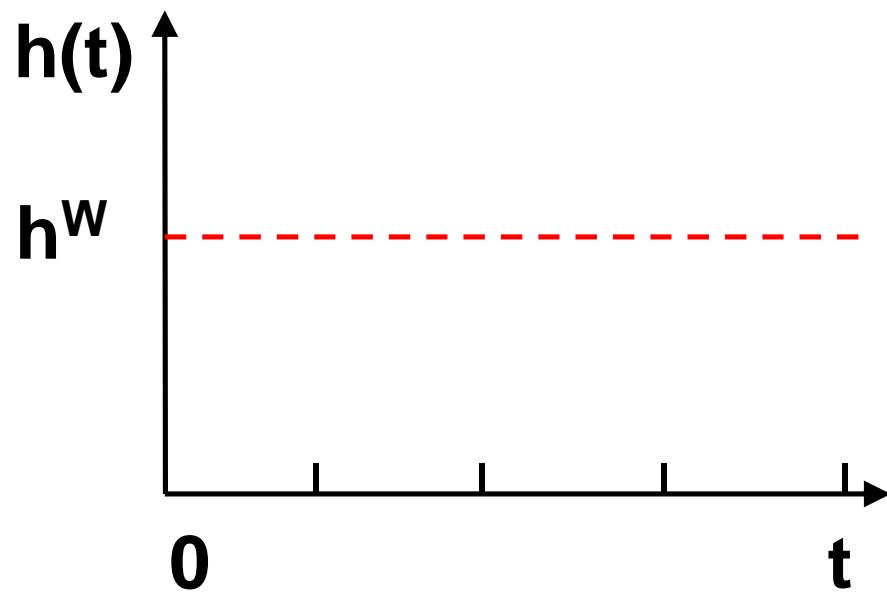
# Zákon riadenia



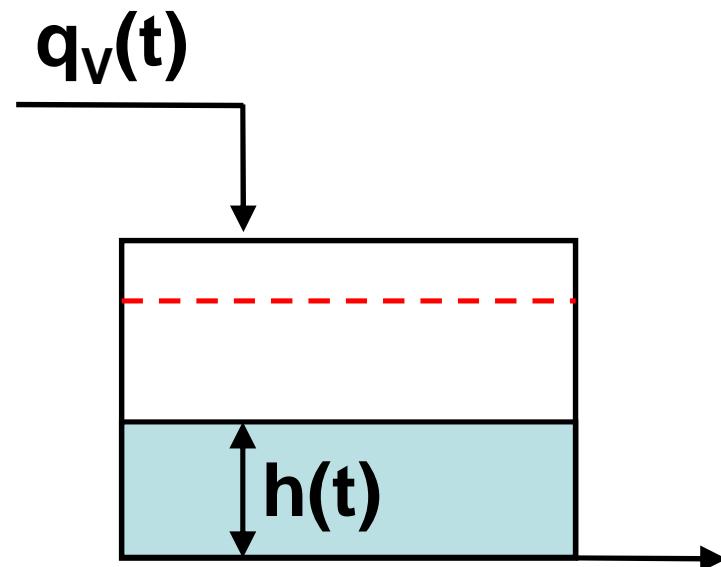
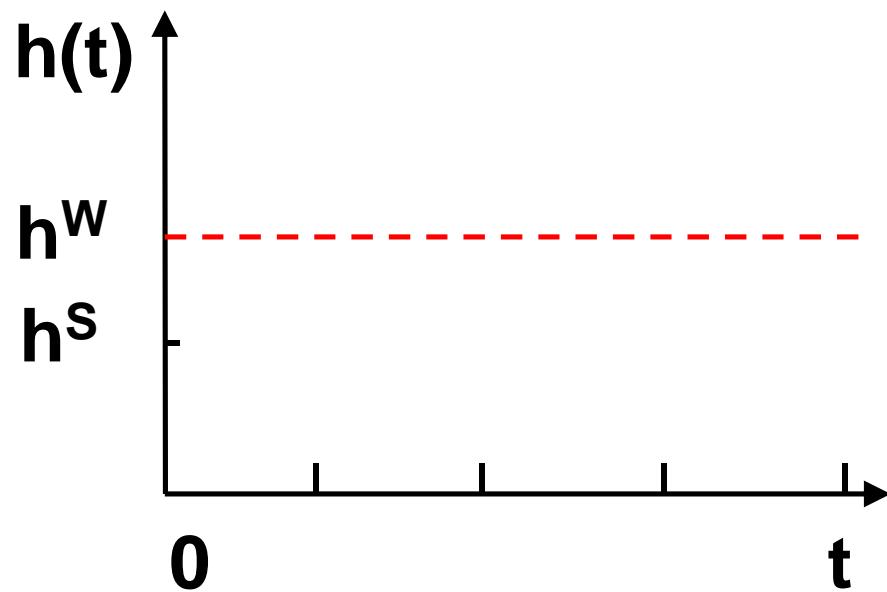
# Zákon riadenia



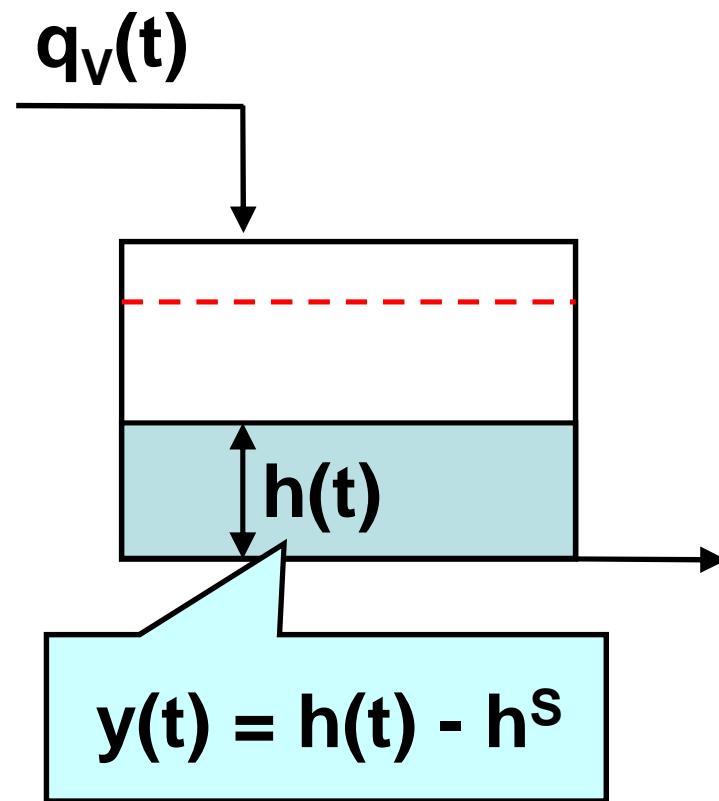
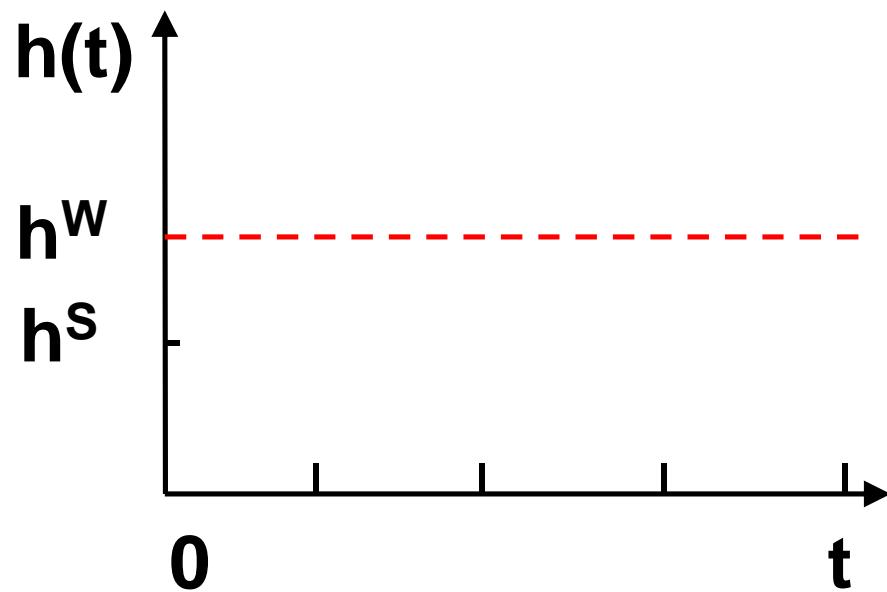
# Zákon riadenia



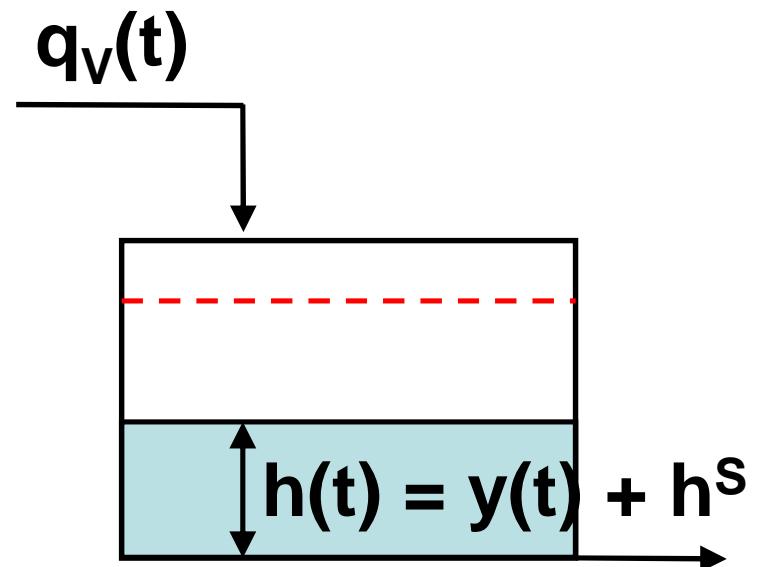
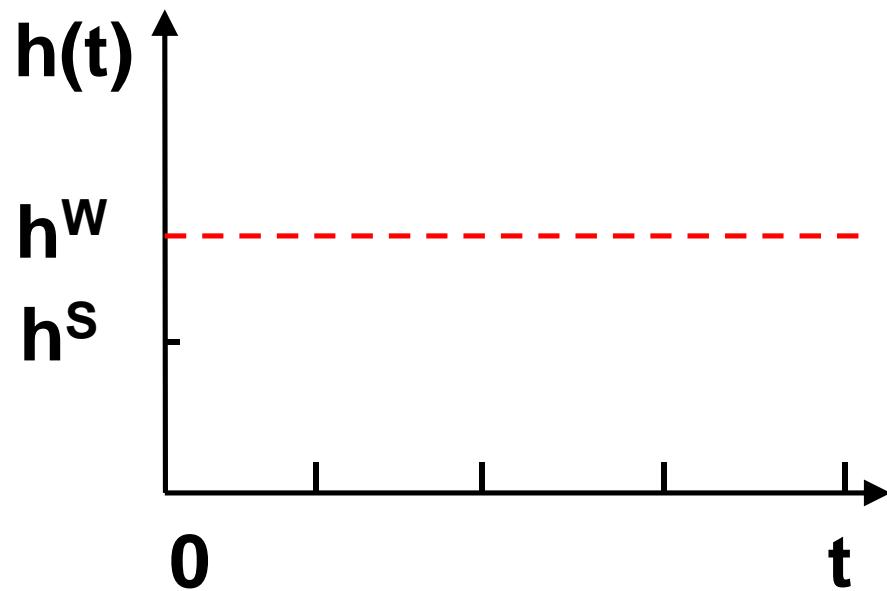
# Zákon riadenia



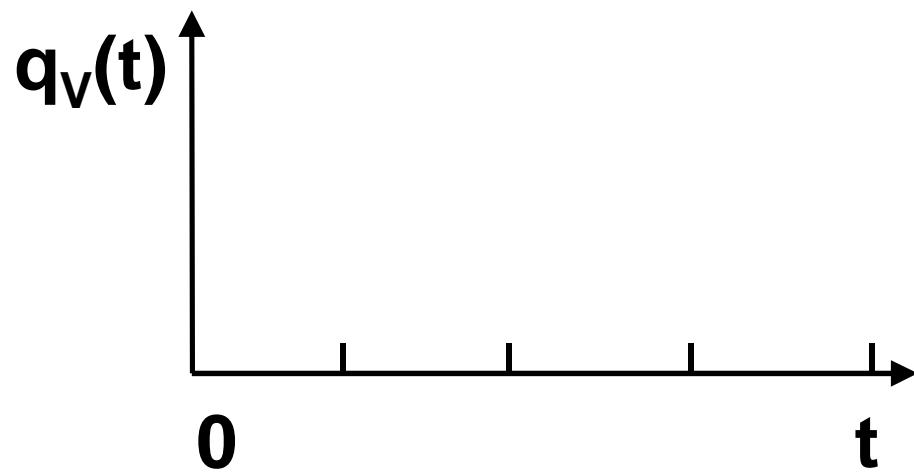
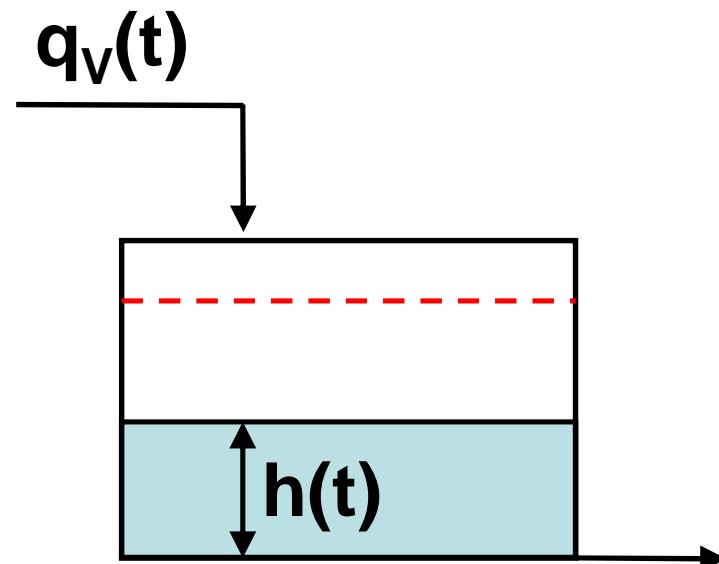
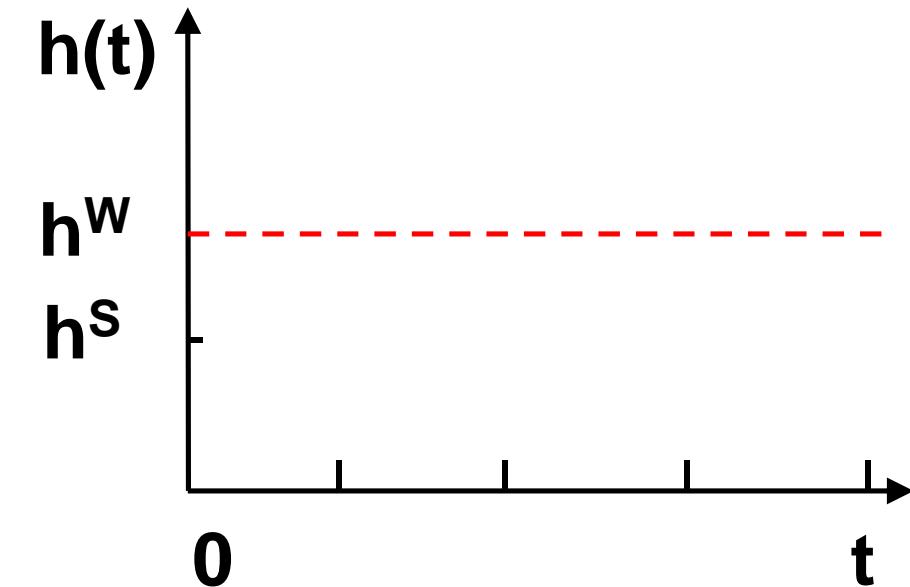
# Zákon riadenia



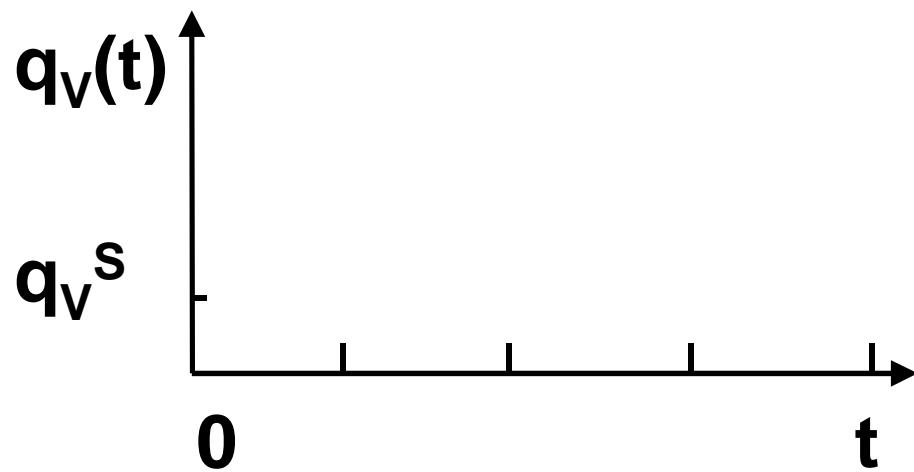
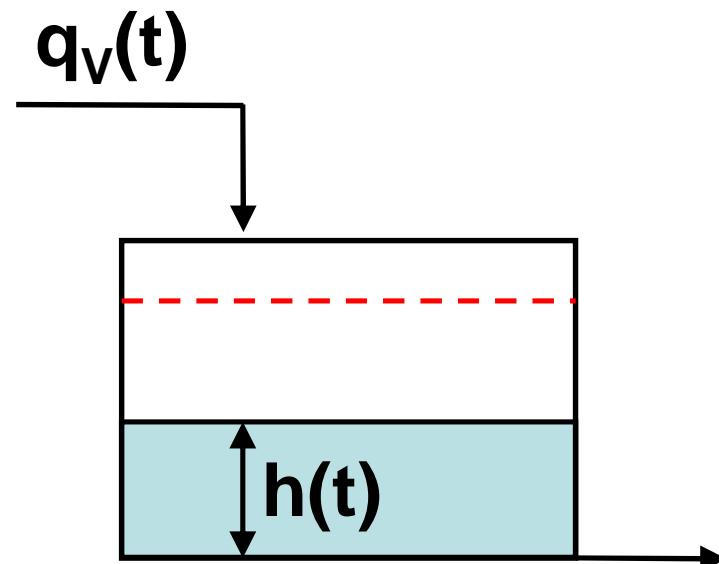
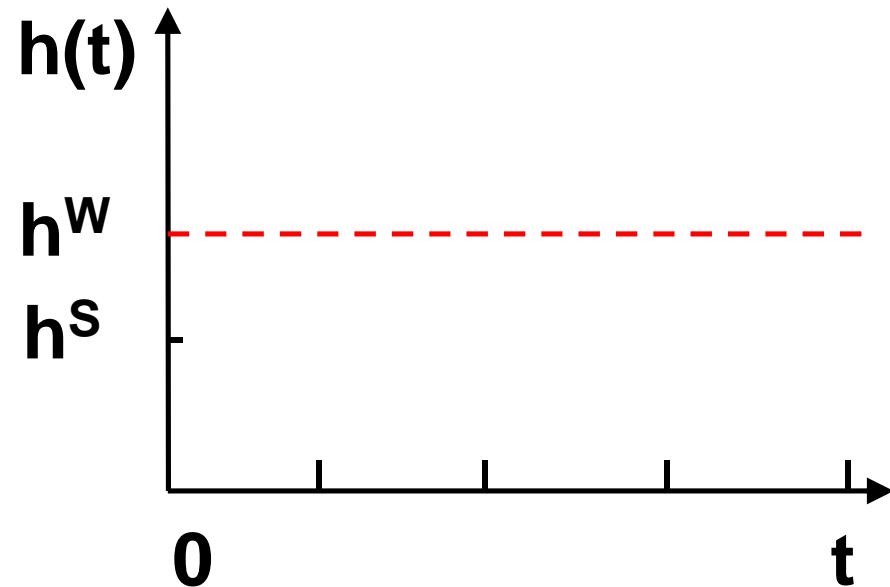
# Zákon riadenia



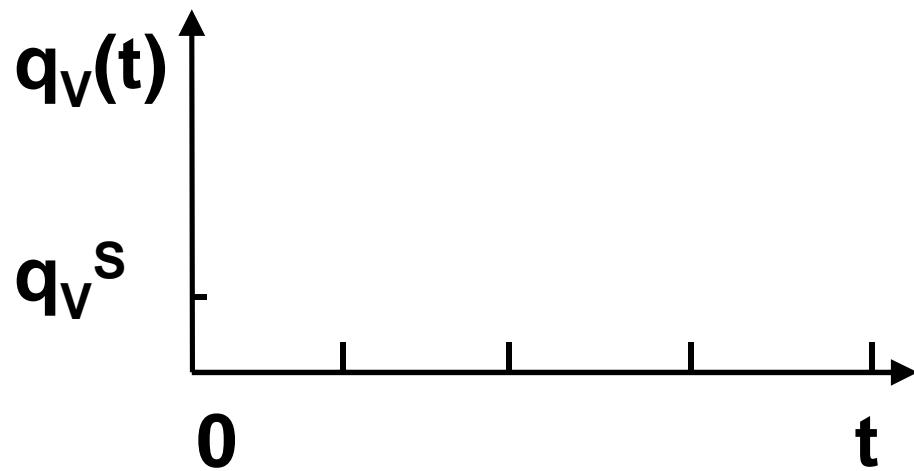
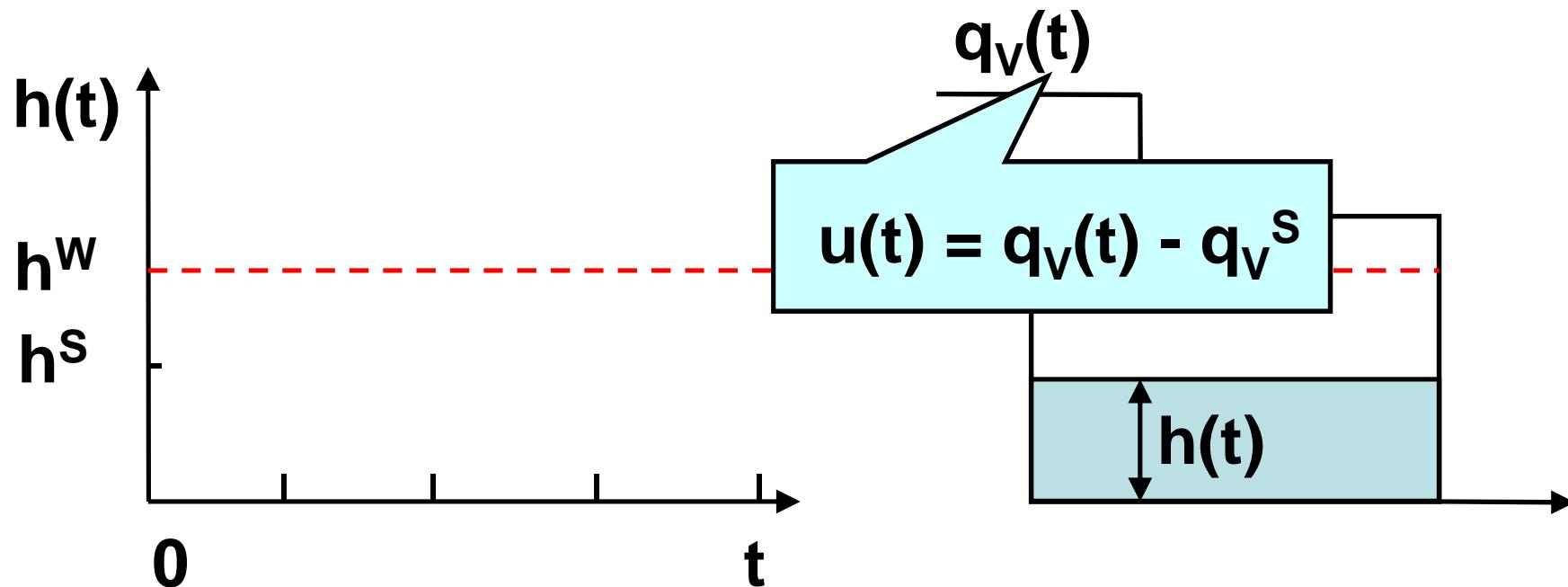
# Zákon riadenia



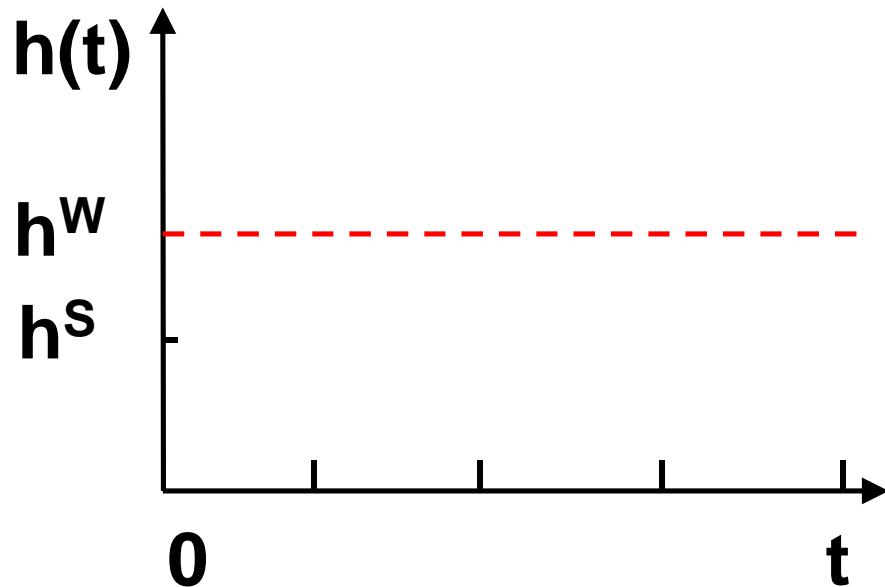
# Zákon riadenia



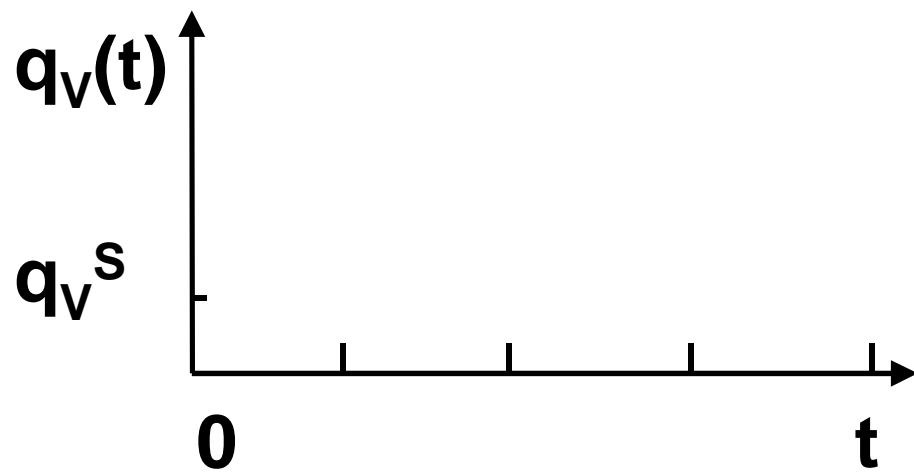
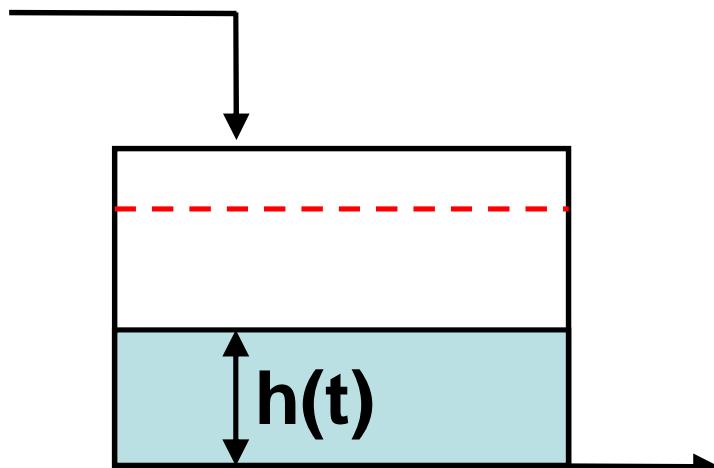
## Zákon riadenia



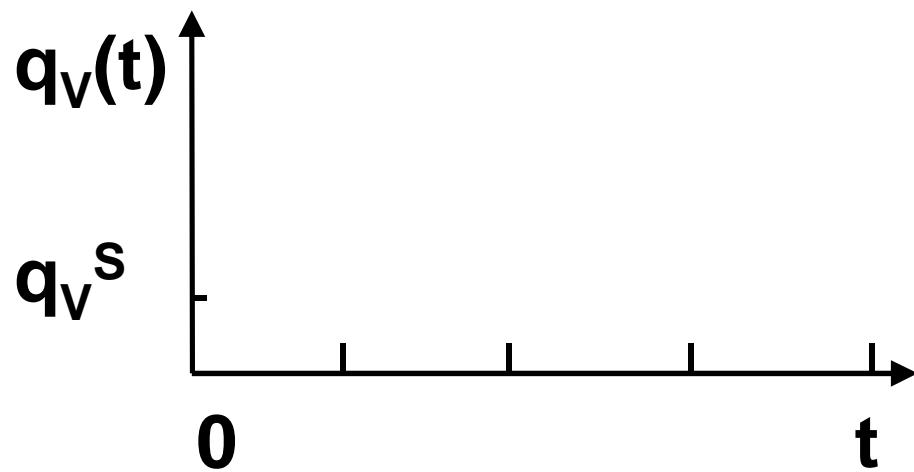
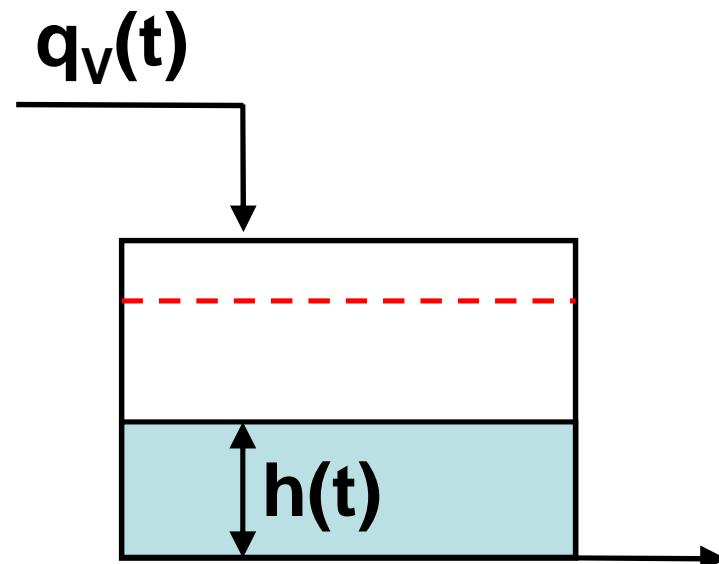
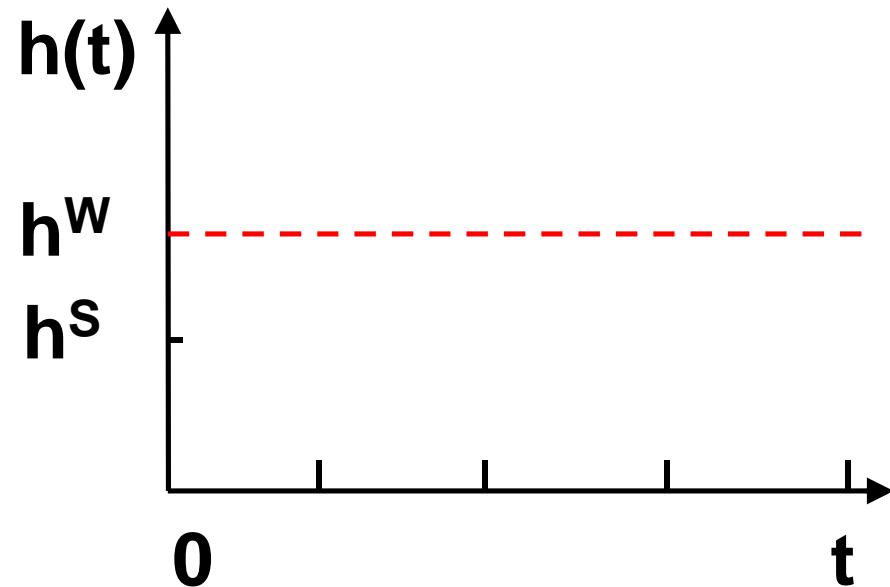
## Zákon riadenia



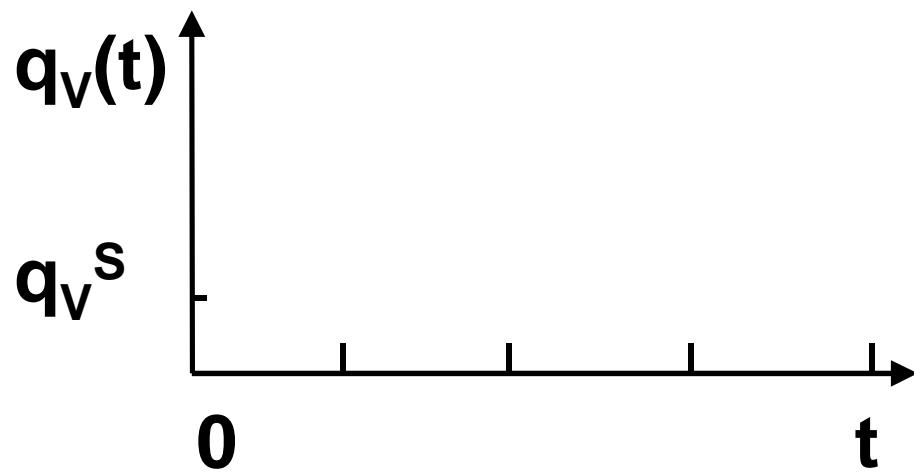
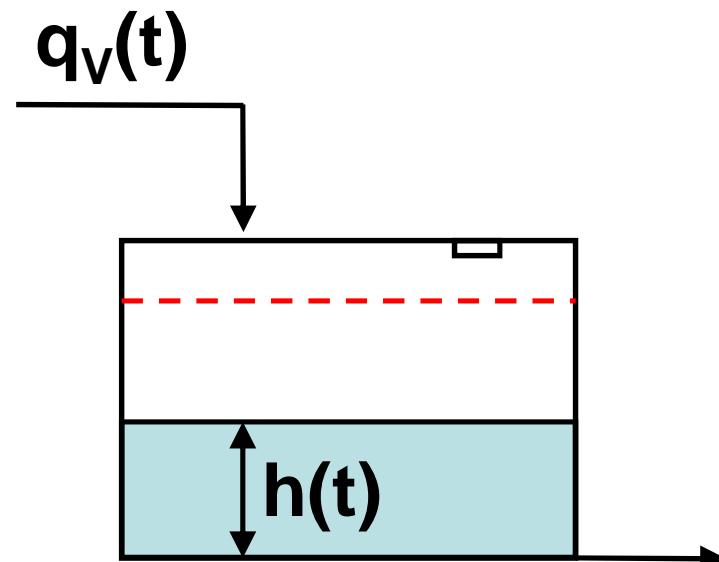
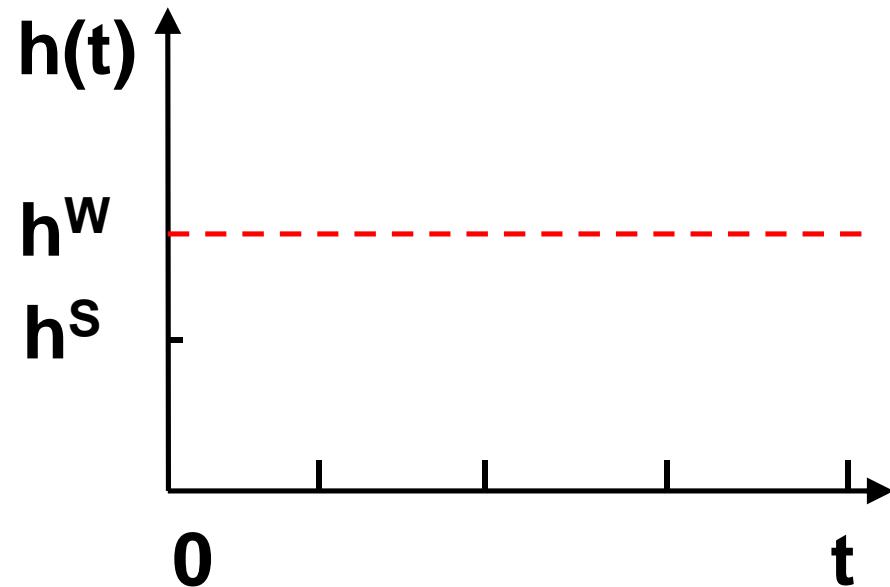
$$q_v(t) = q_v^s + u(t)$$



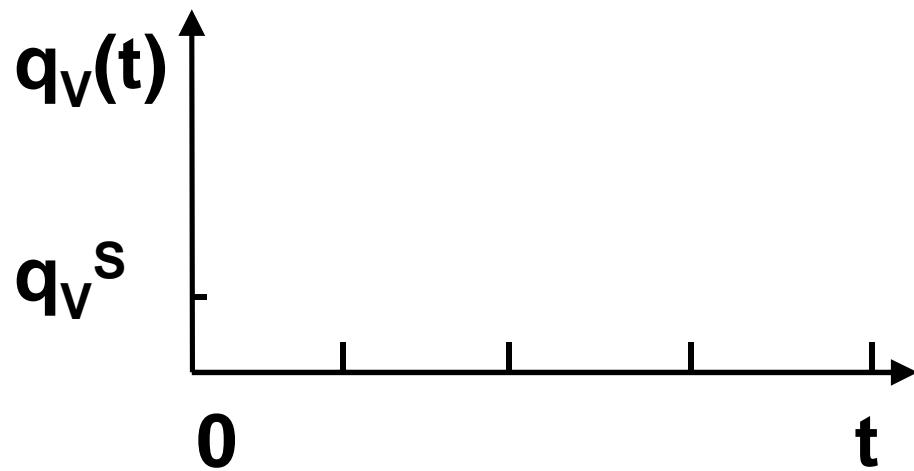
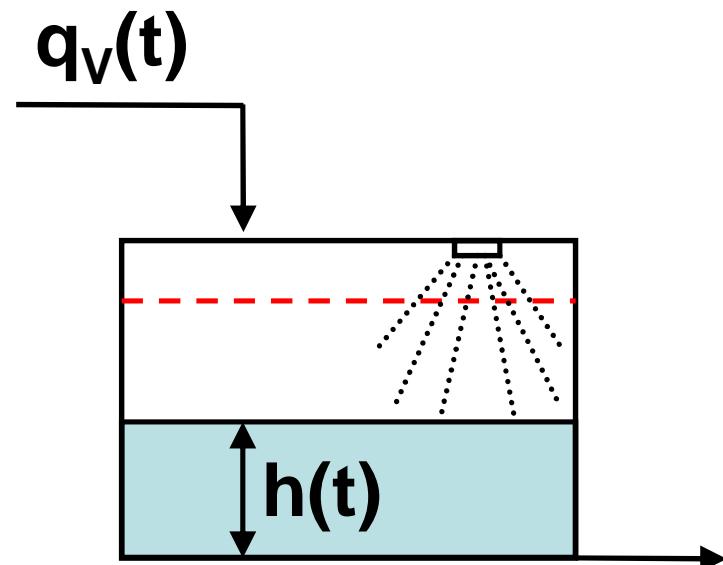
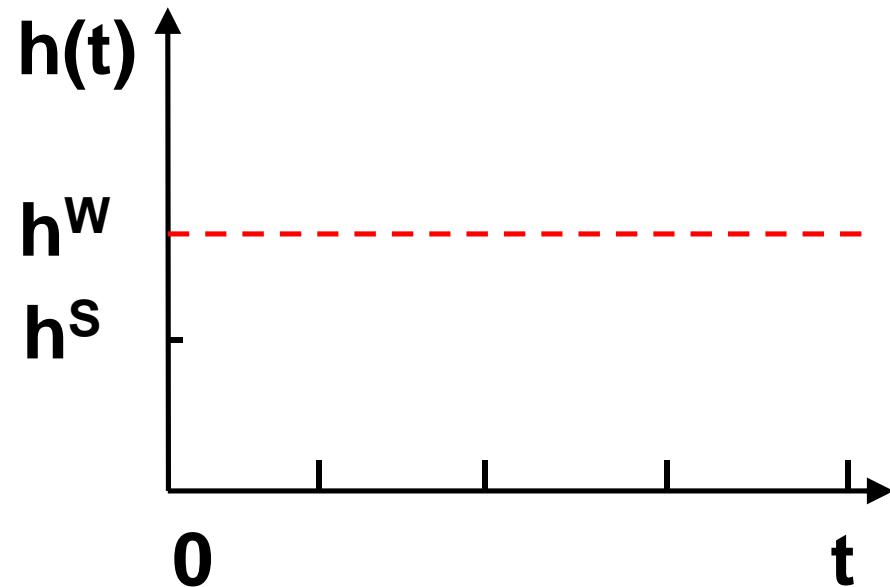
# Zákon riadenia



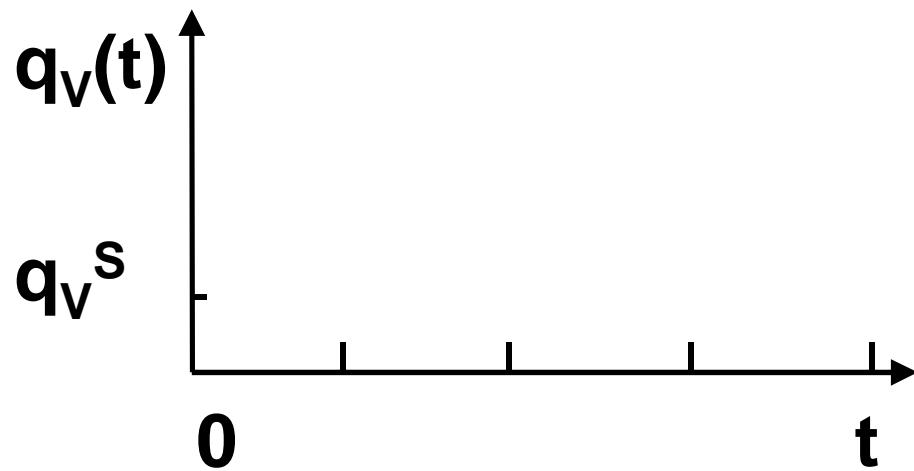
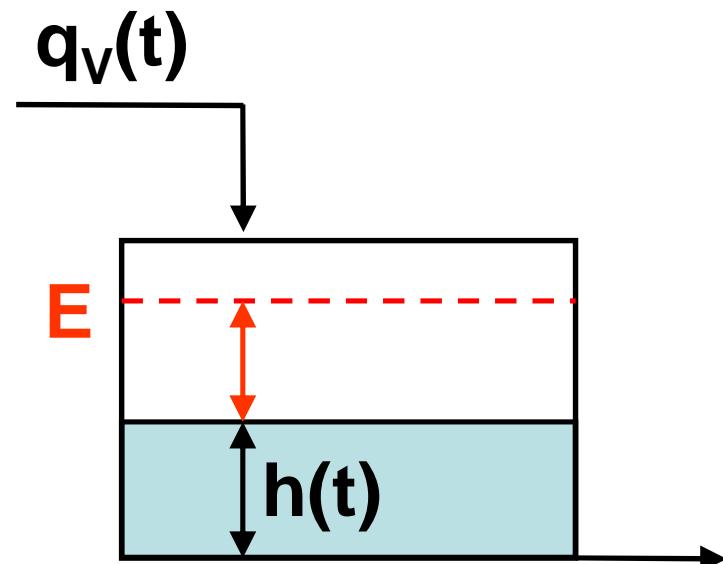
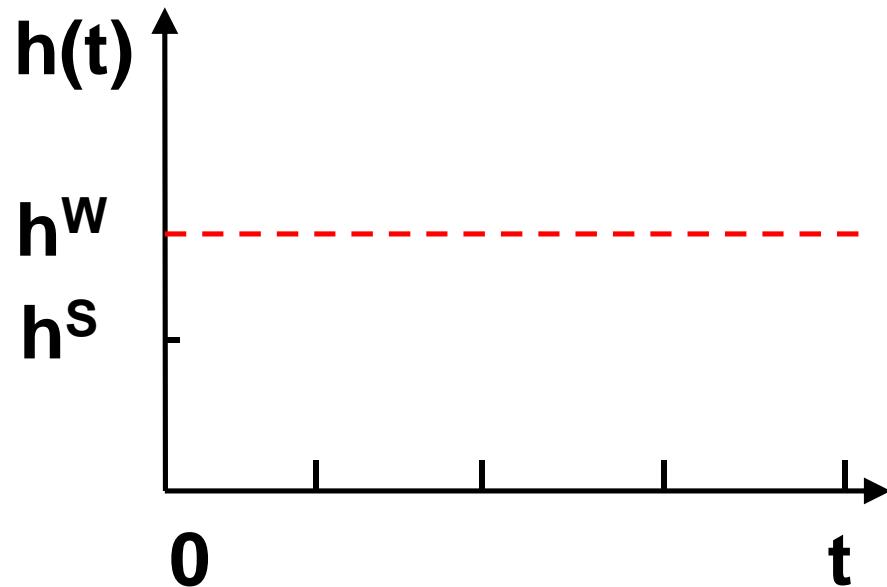
# Zákon riadenia



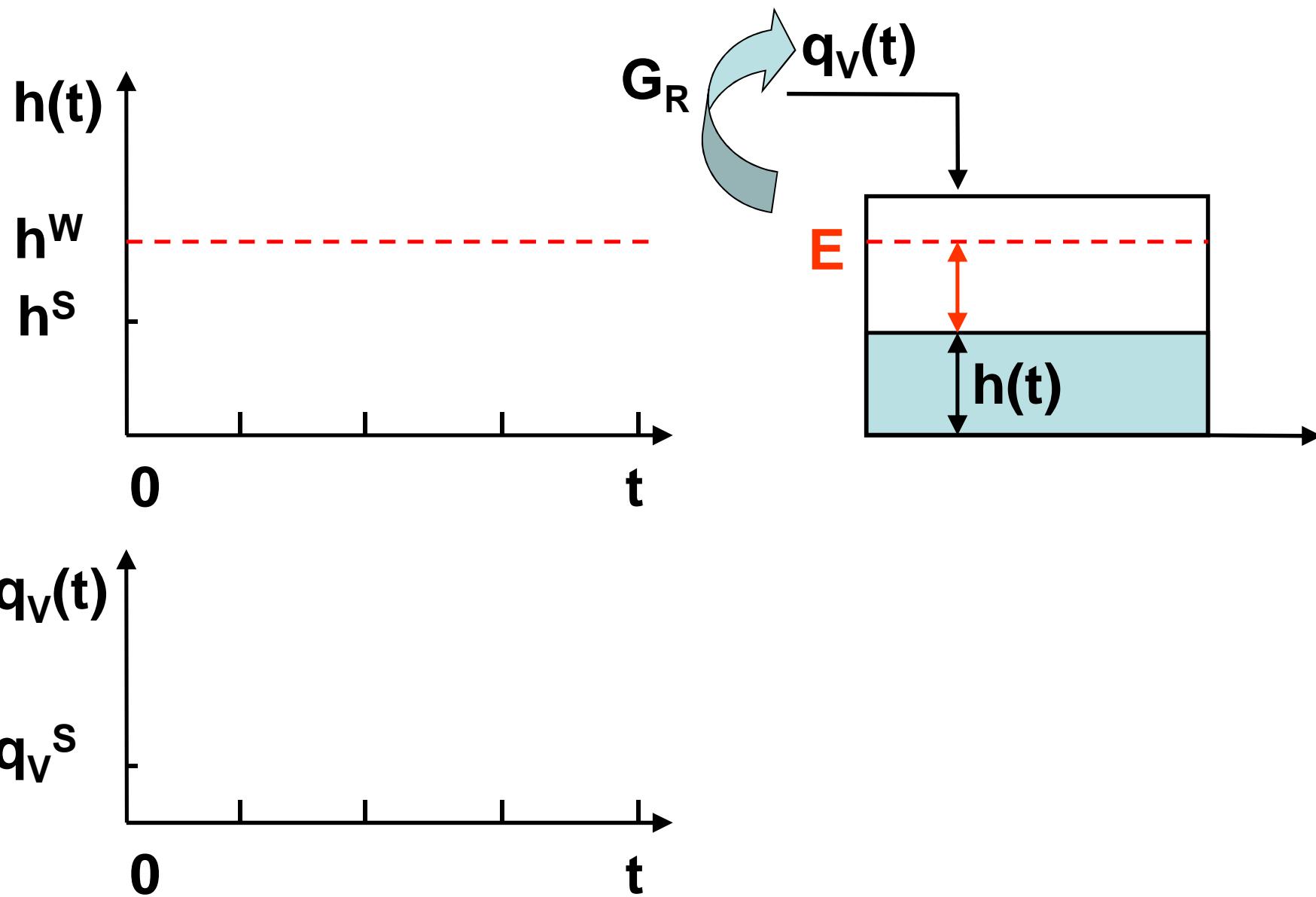
# Zákon riadenia



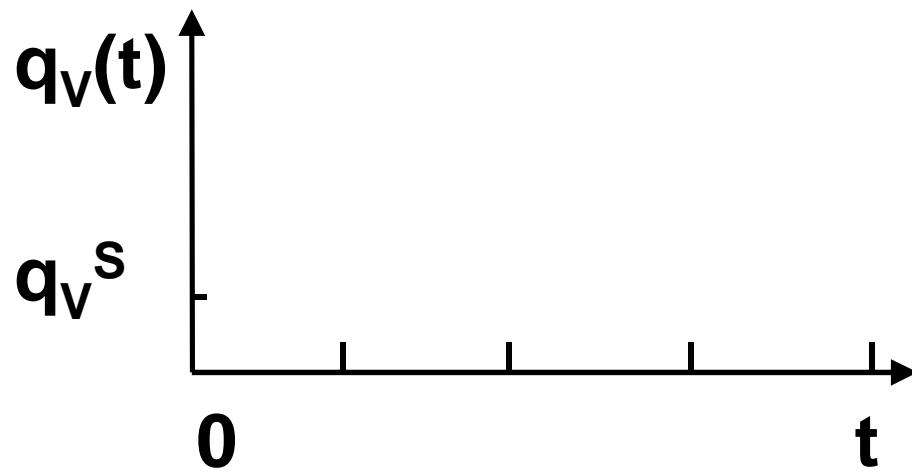
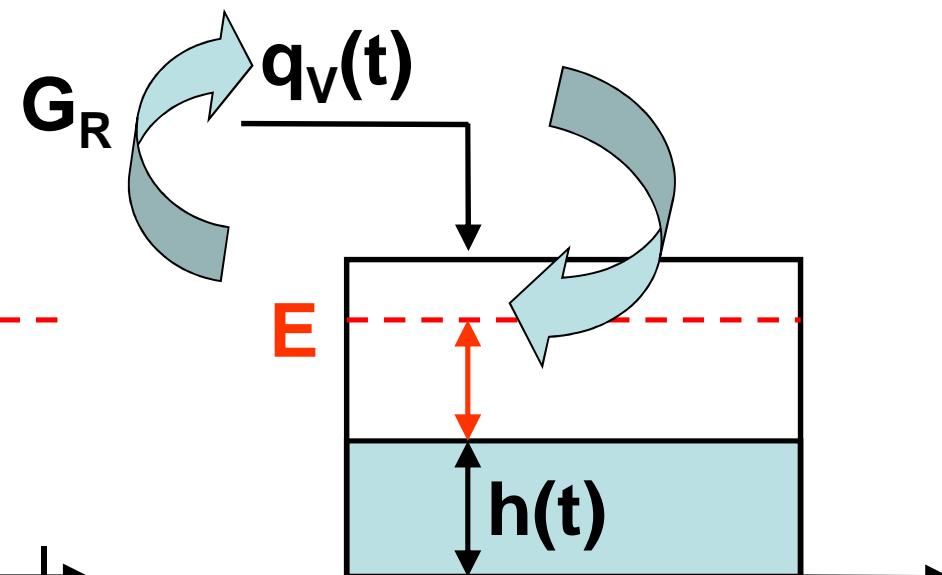
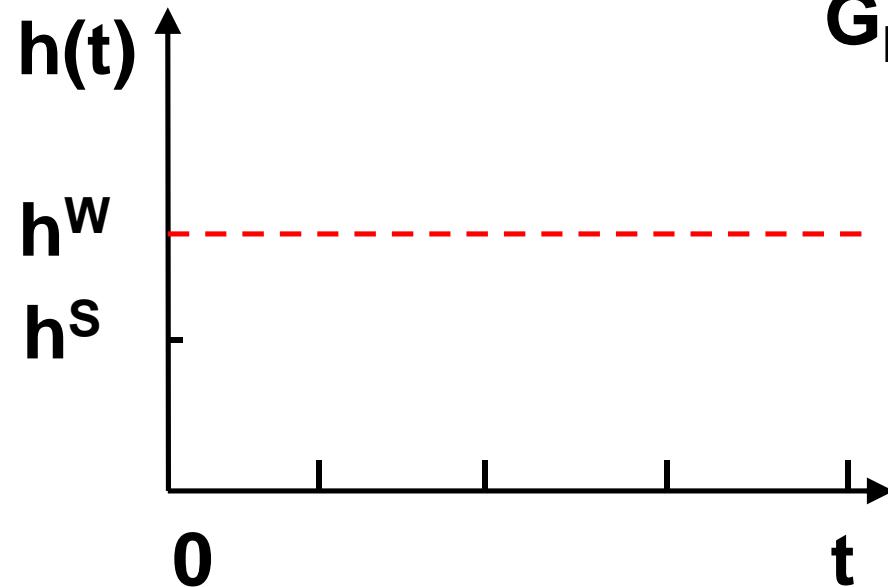
# Zákon riadenia



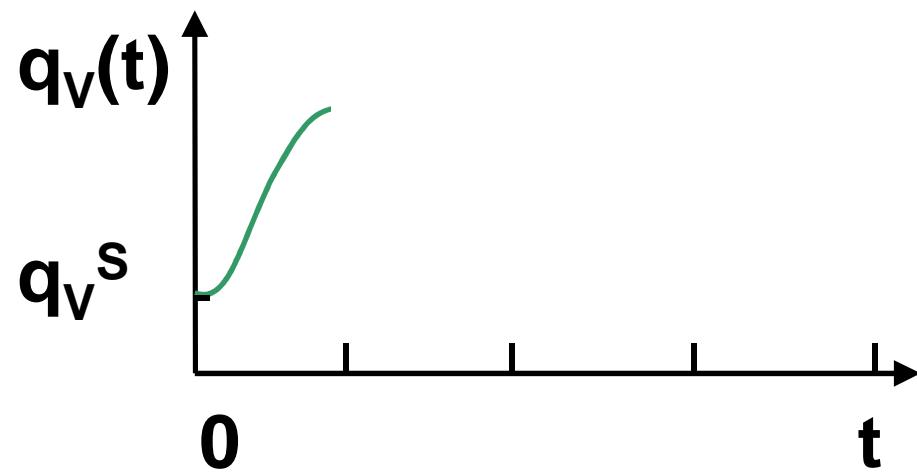
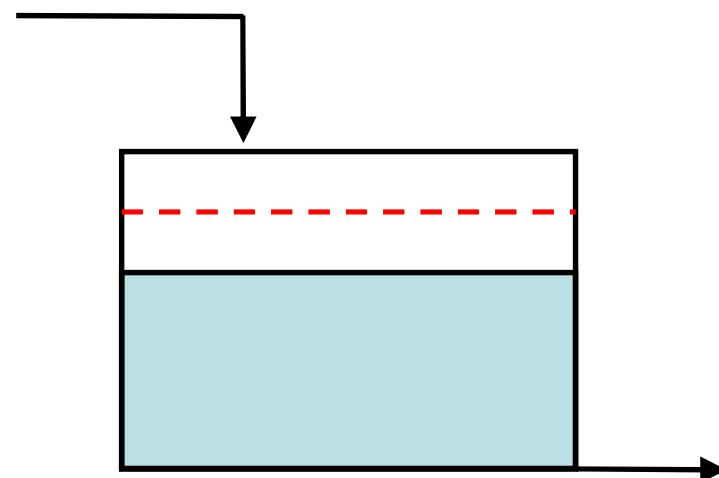
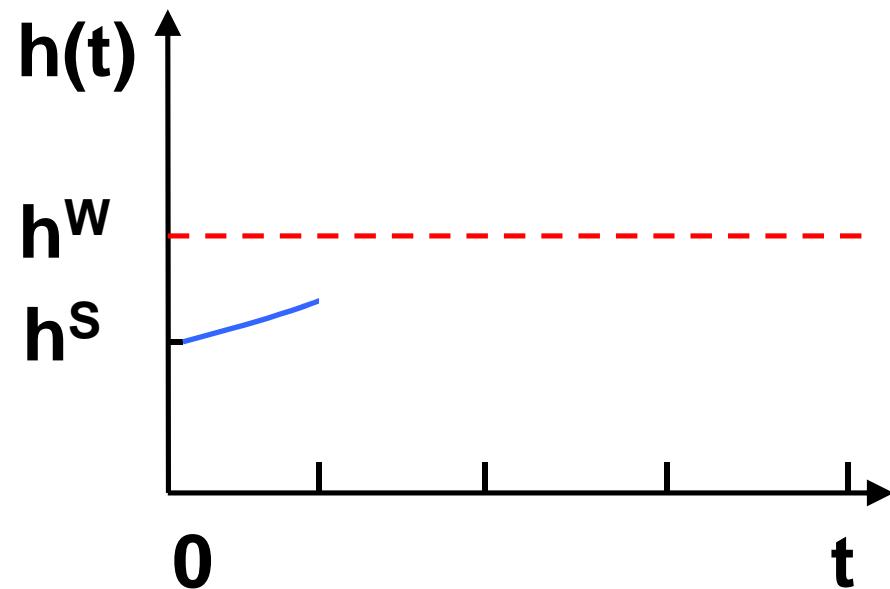
## Zákon riadenia



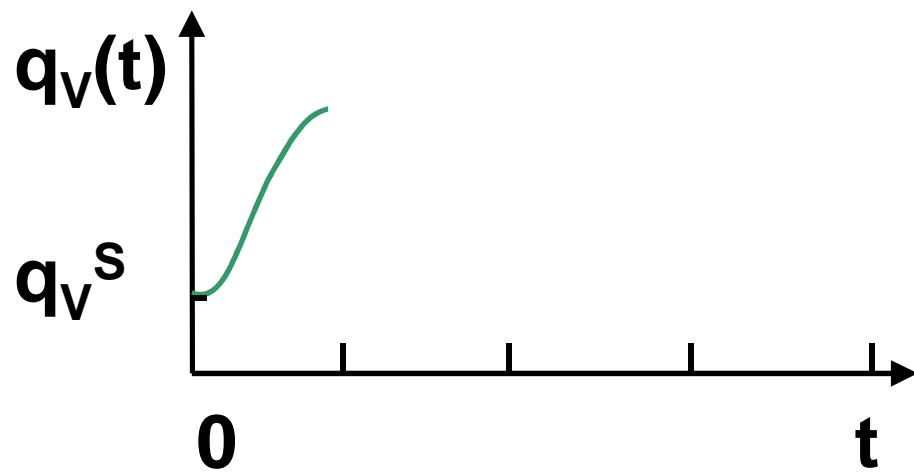
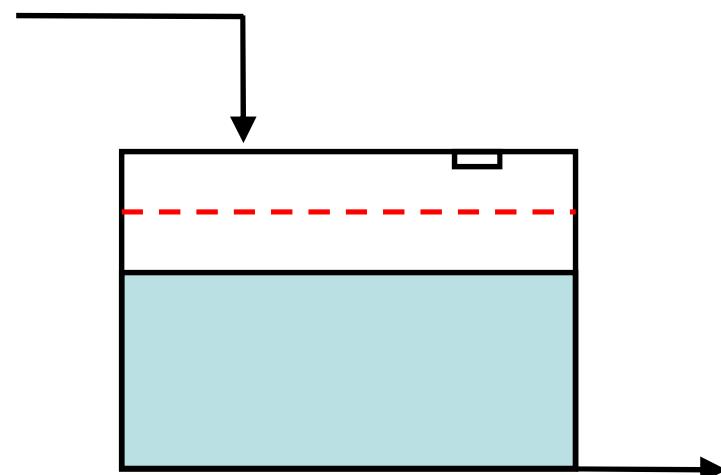
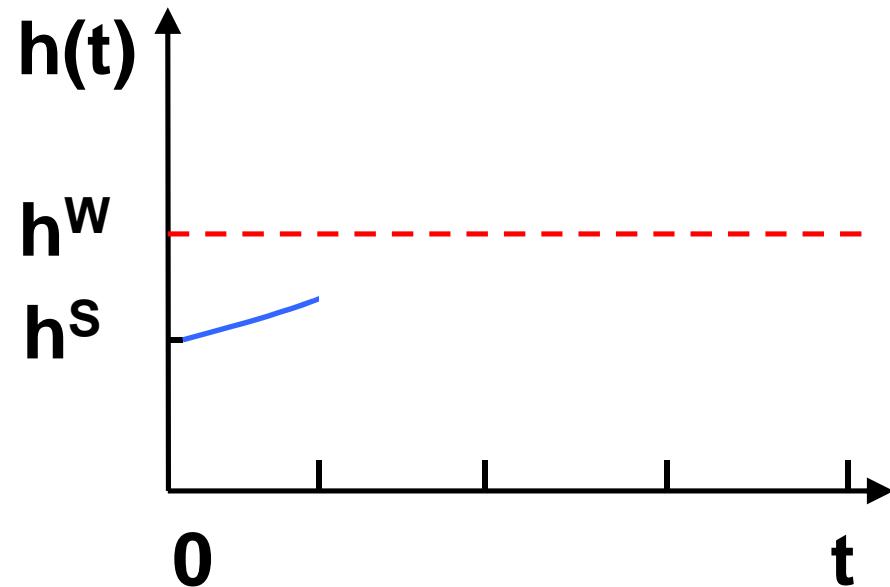
## Zákon riadenia



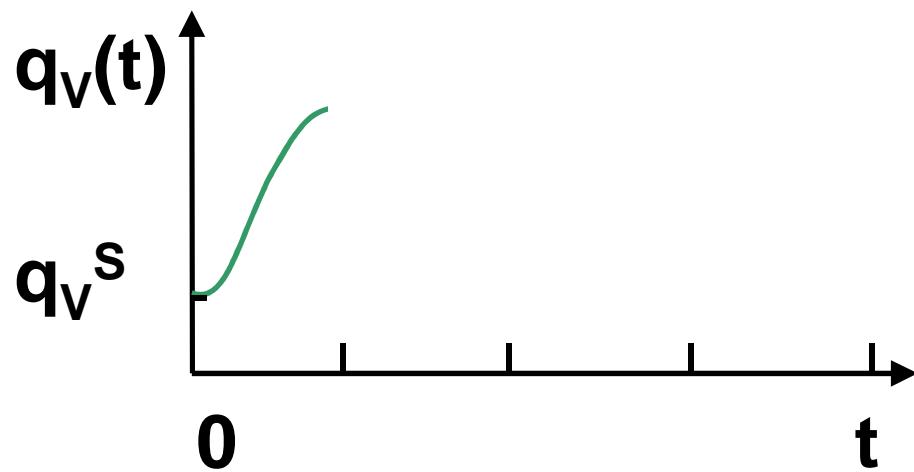
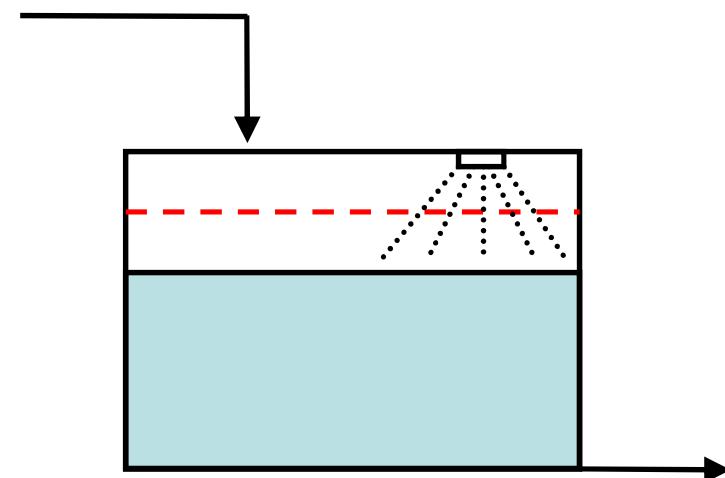
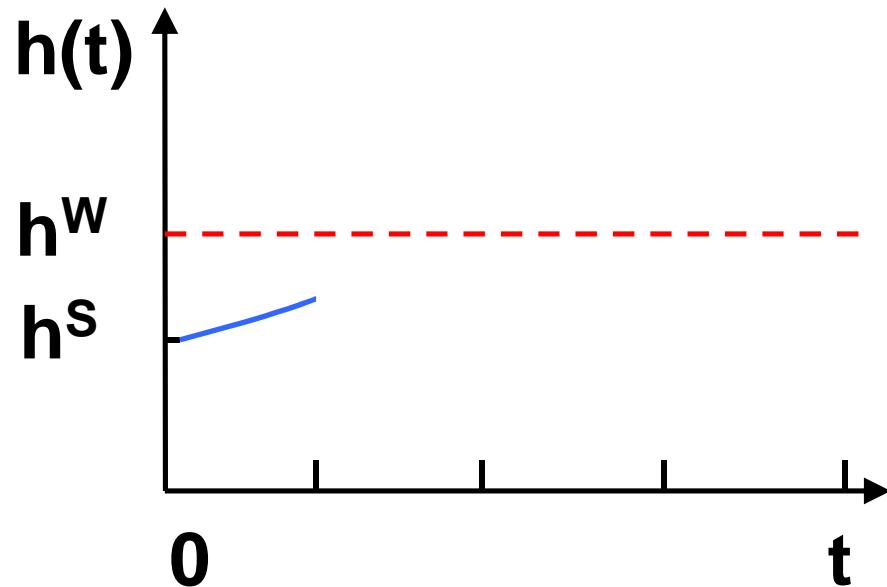
# Zákon riadenia



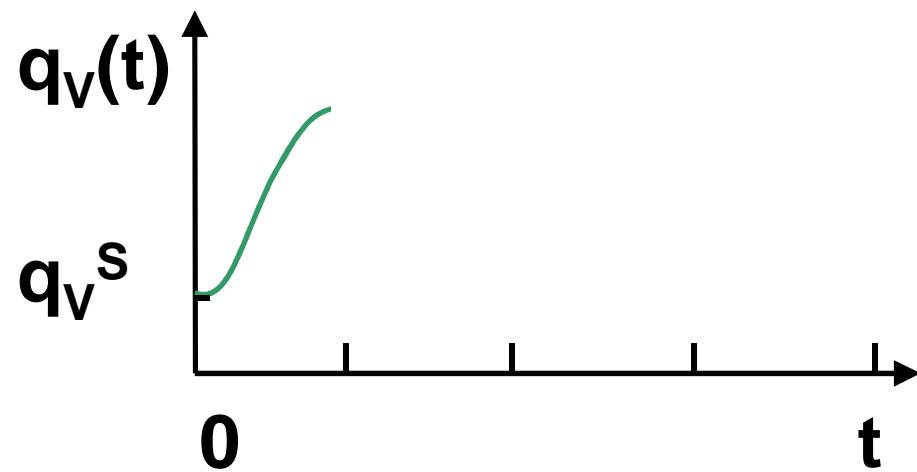
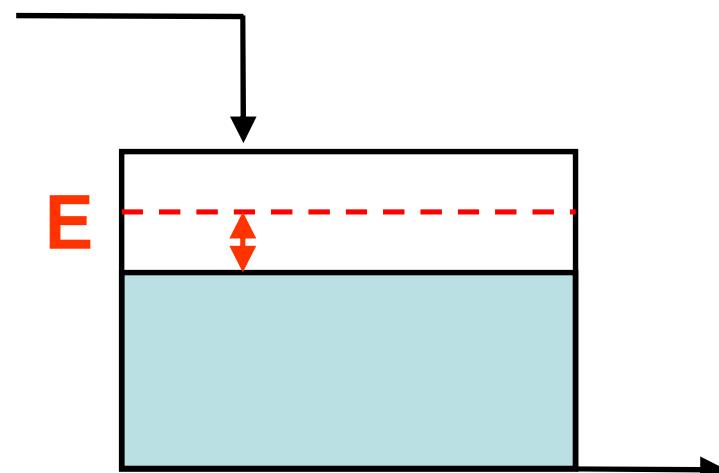
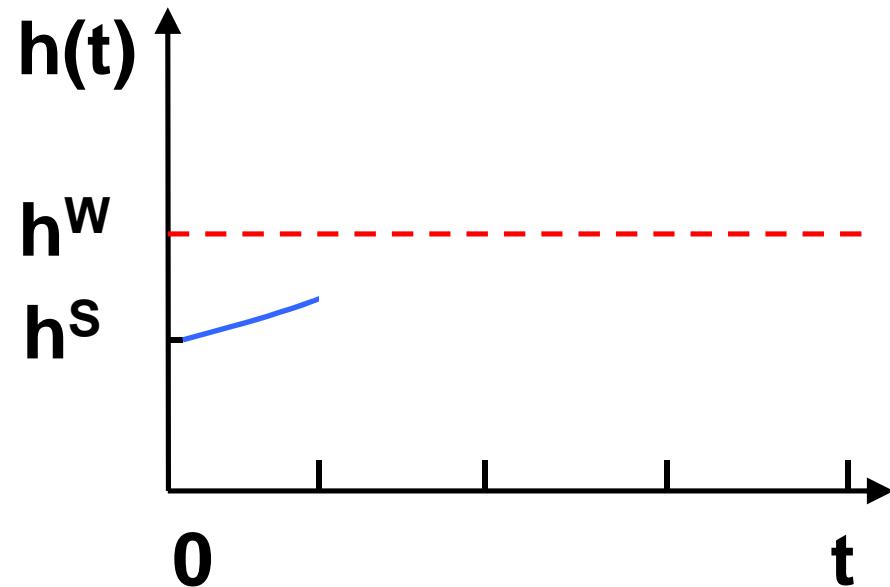
# Zákon riadenia



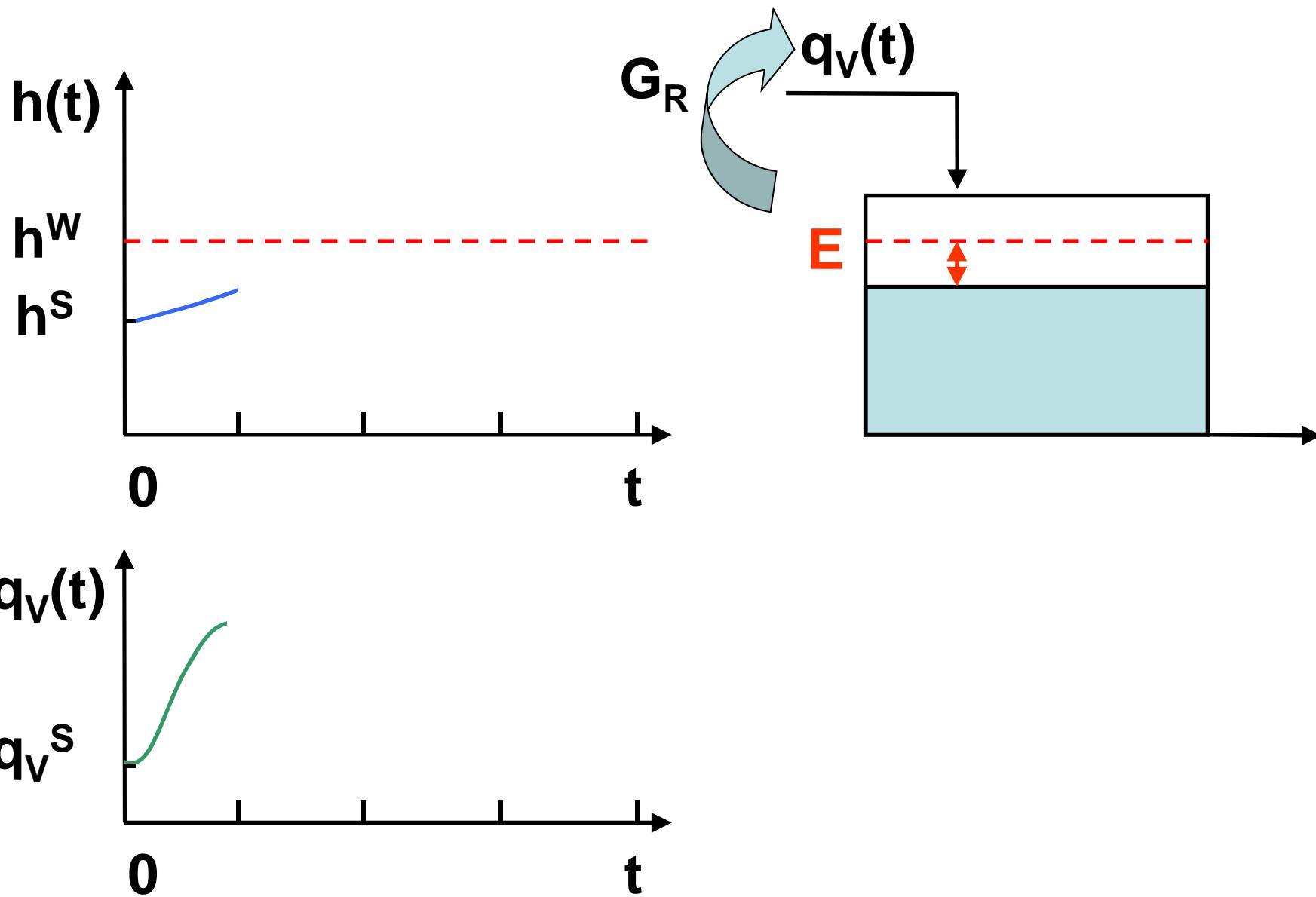
# Zákon riadenia



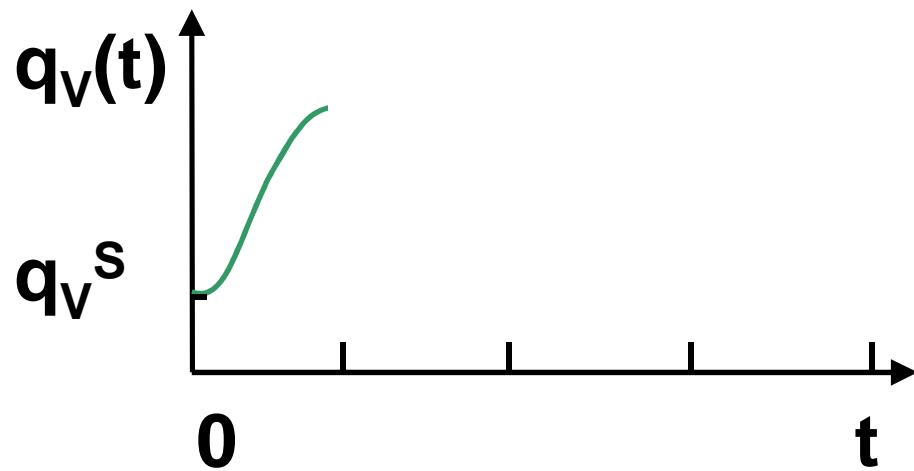
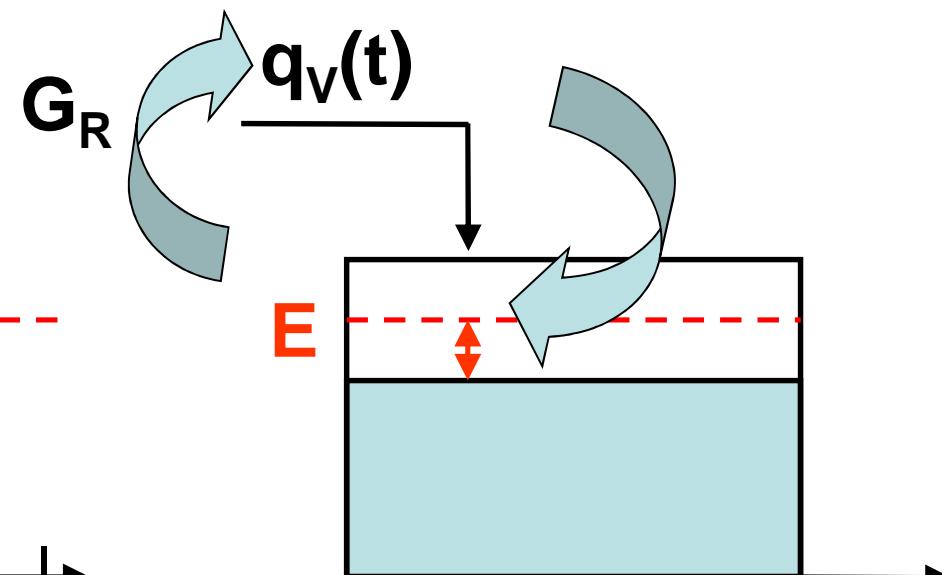
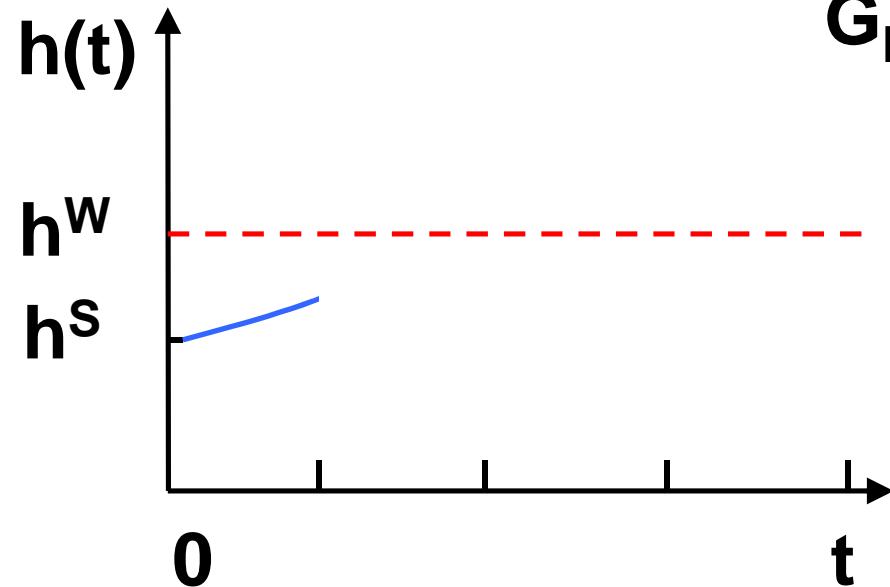
# Zákon riadenia



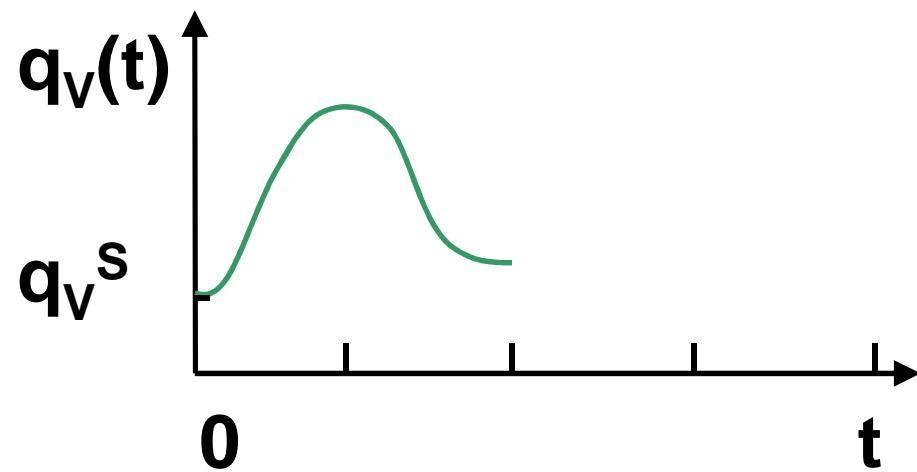
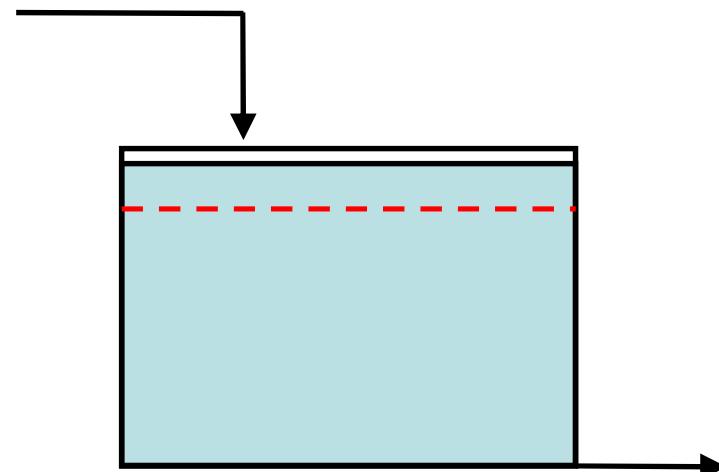
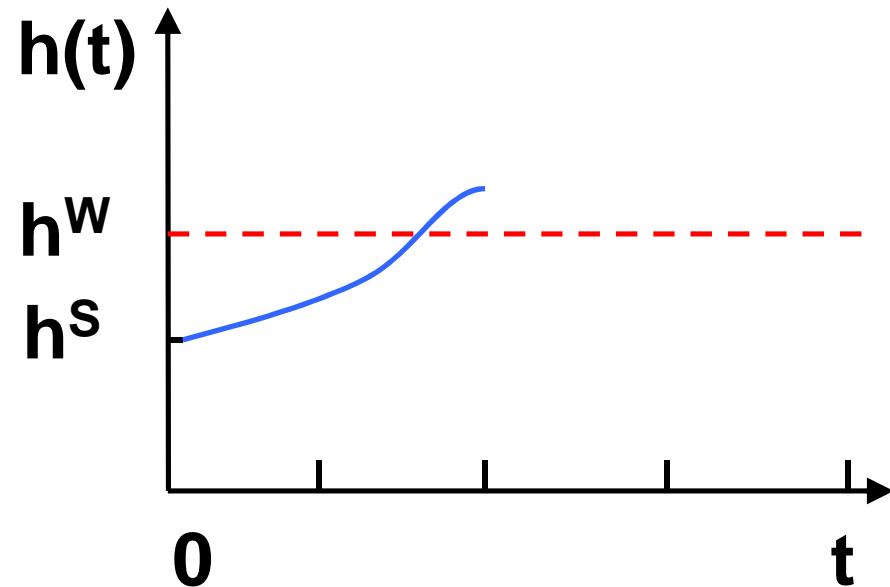
## Zákon riadenia



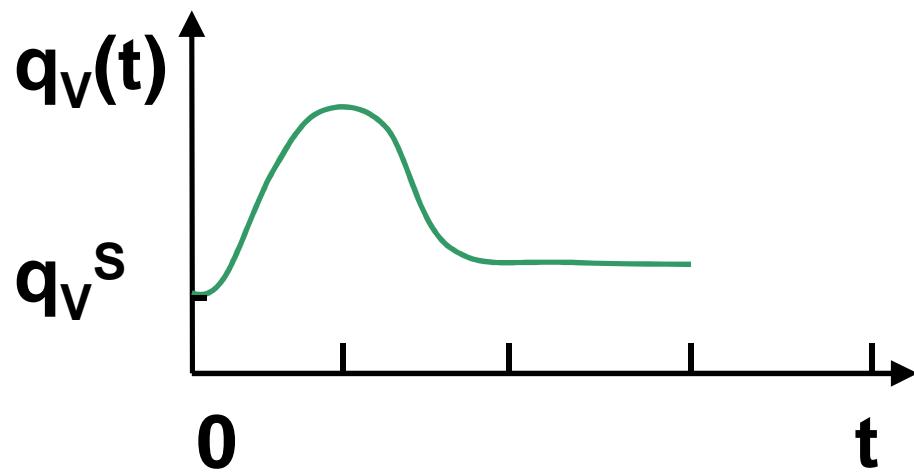
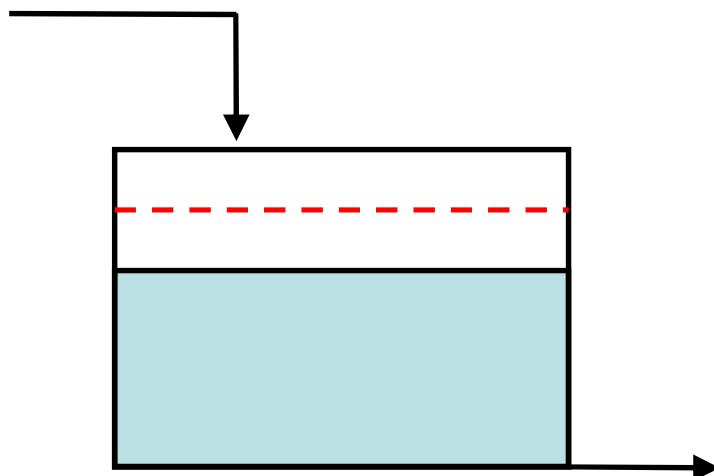
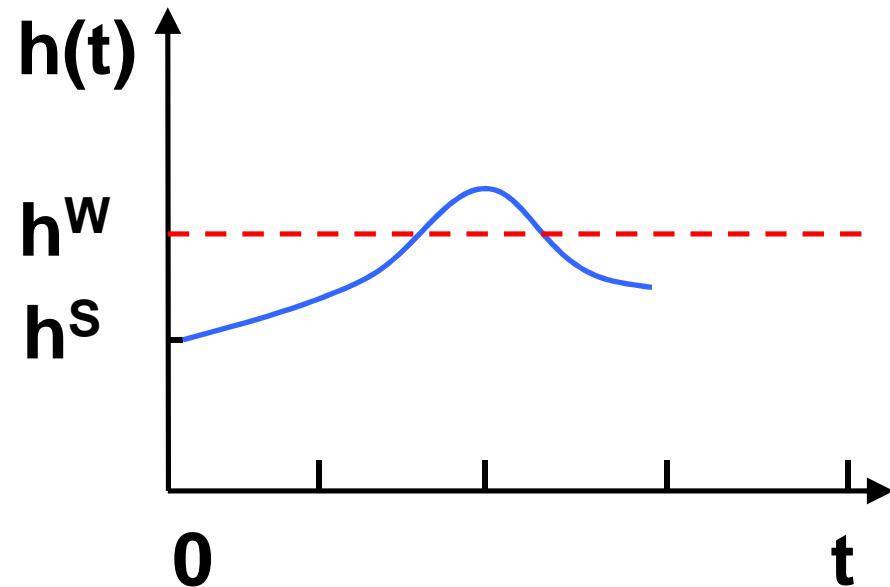
## Zákon riadenia



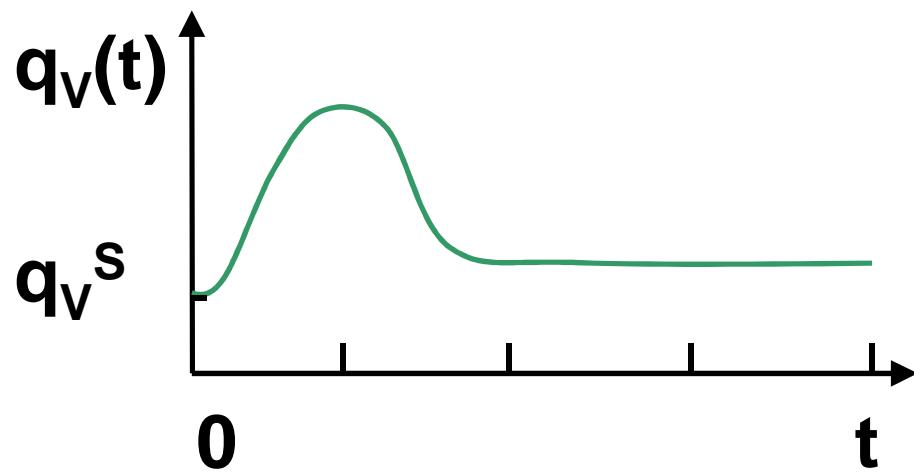
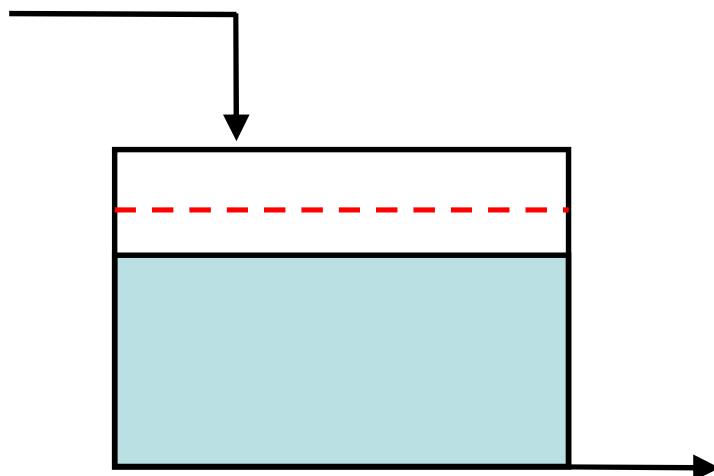
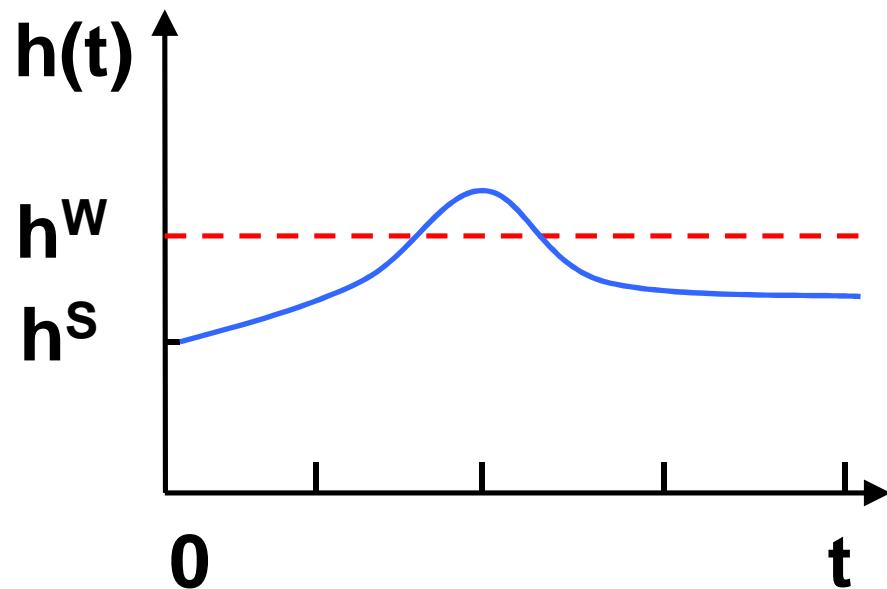
# Zákon riadenia



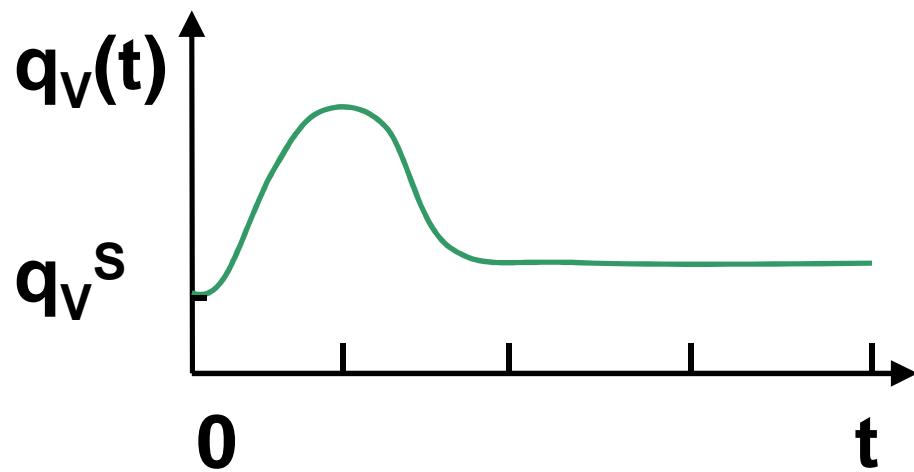
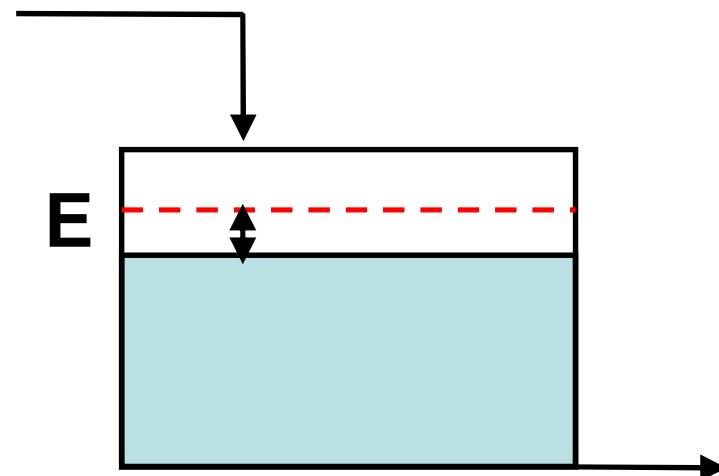
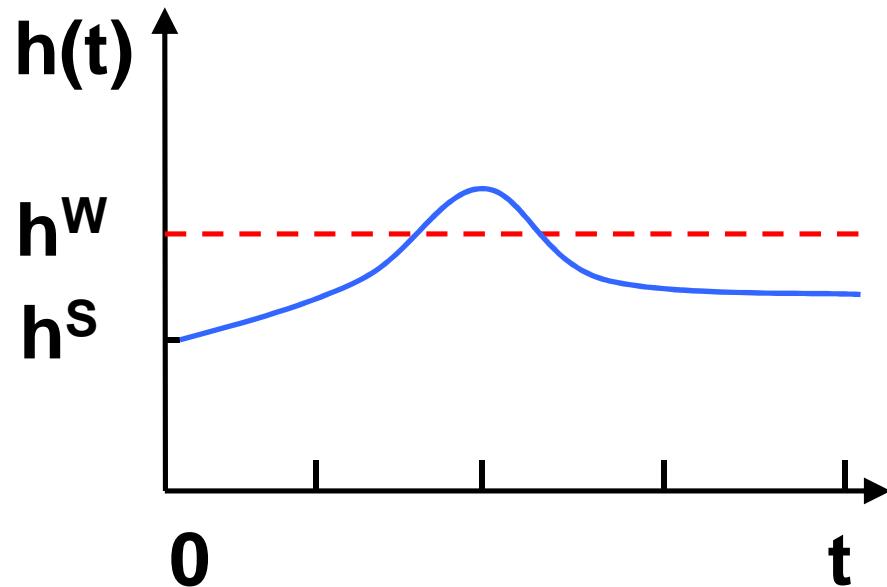
# Zákon riadenia



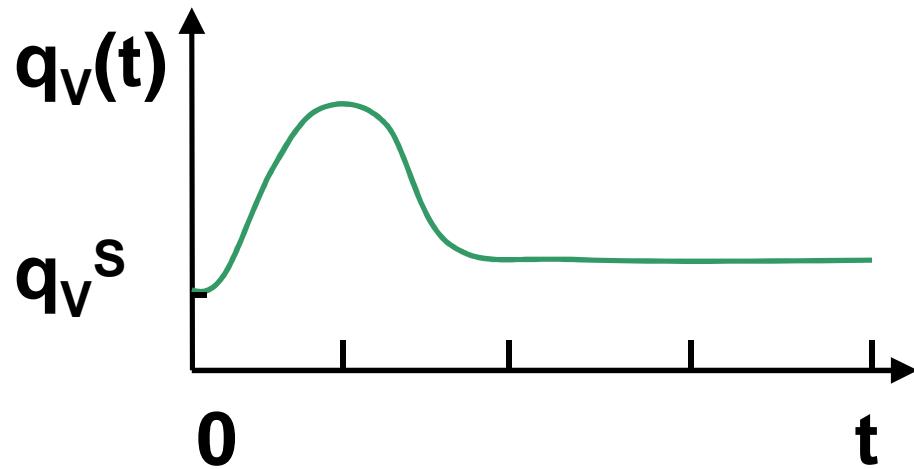
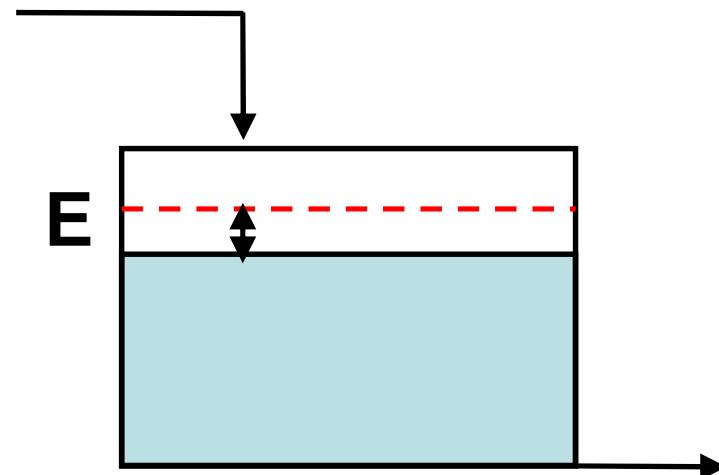
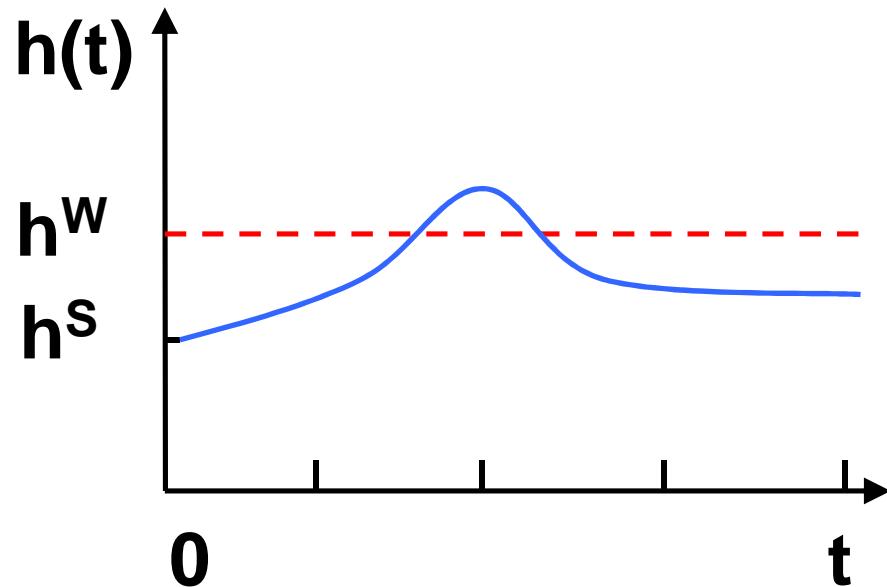
# Zákon riadenia



# Zákon riadenia

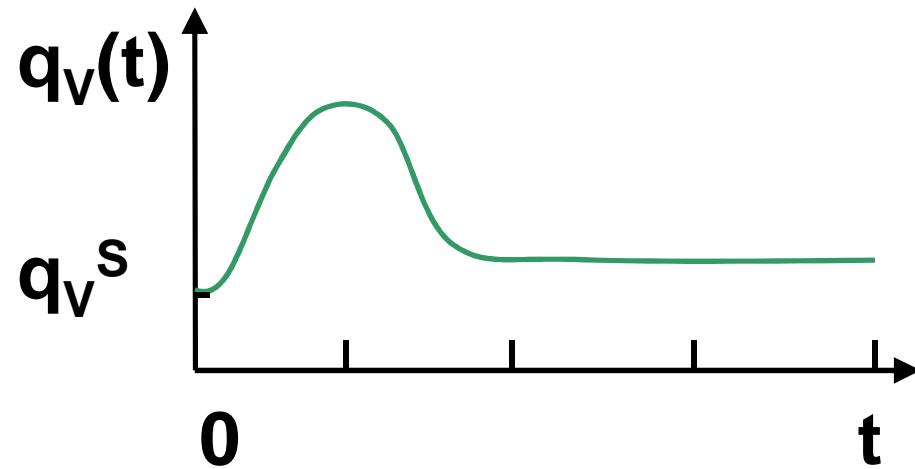
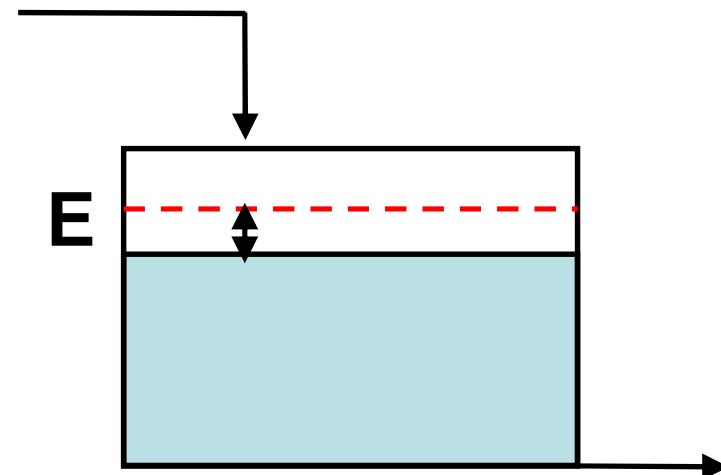
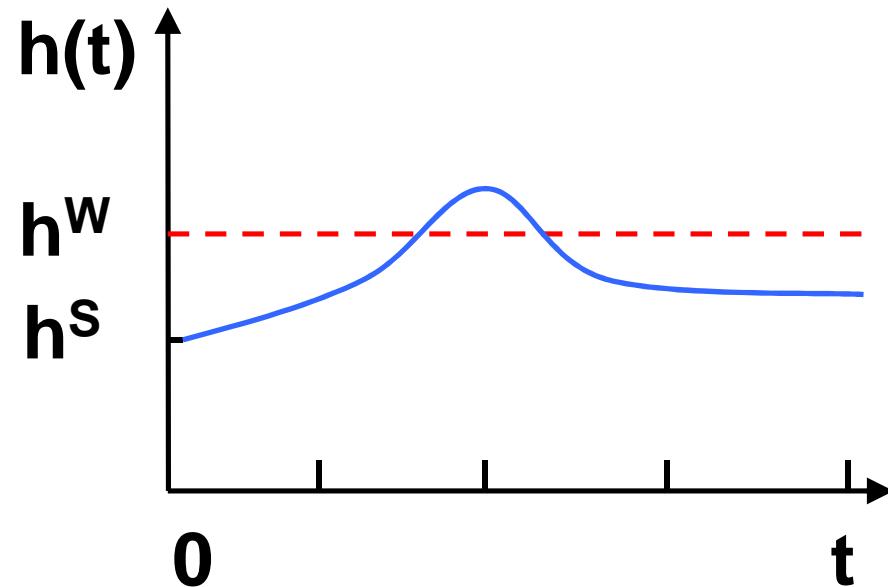


# Zákon riadenia



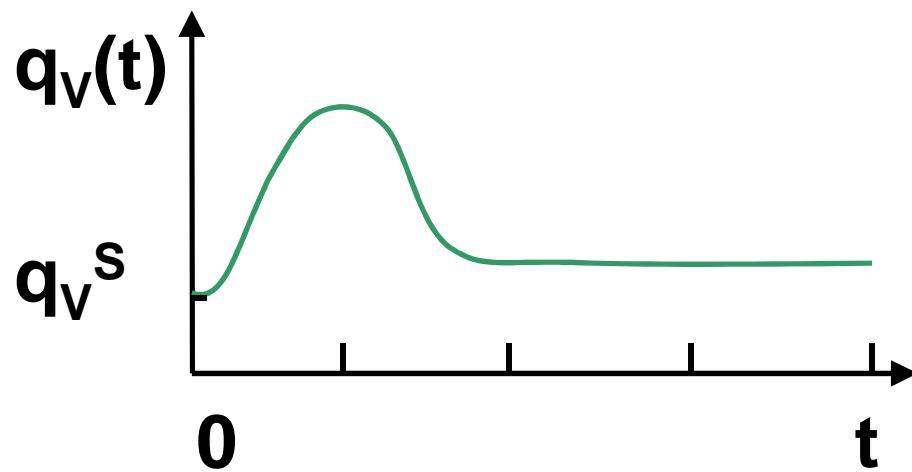
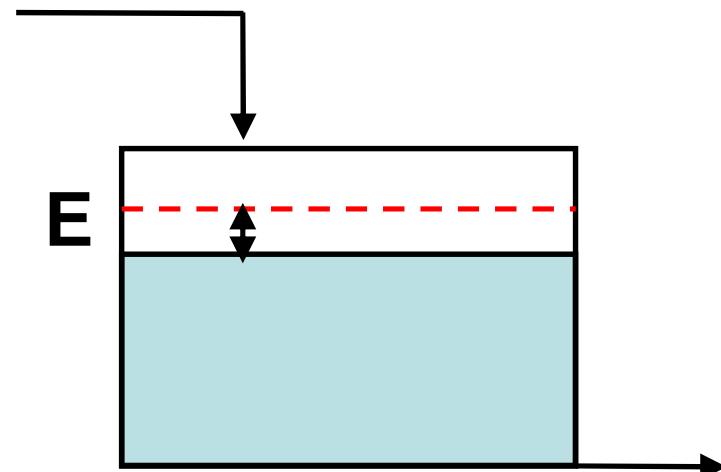
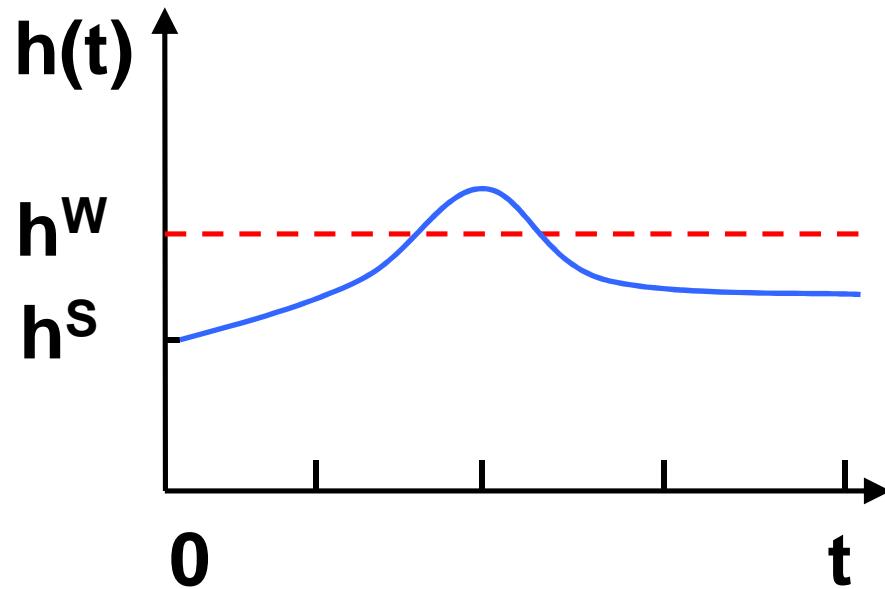
$$E = W - Y$$

# Zákon riadenia



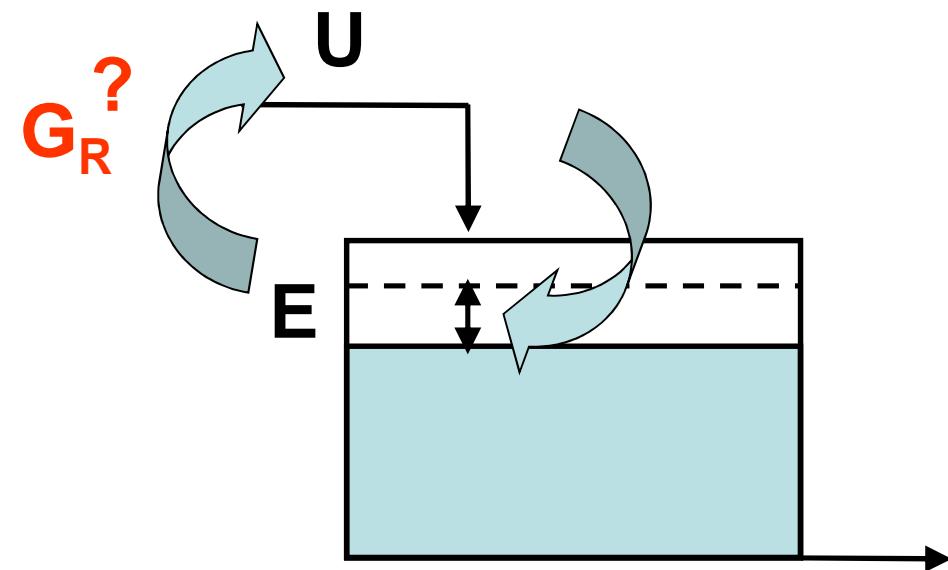
$$E(\infty) = W(\infty) - Y(\infty)$$

# Zákon riadenia

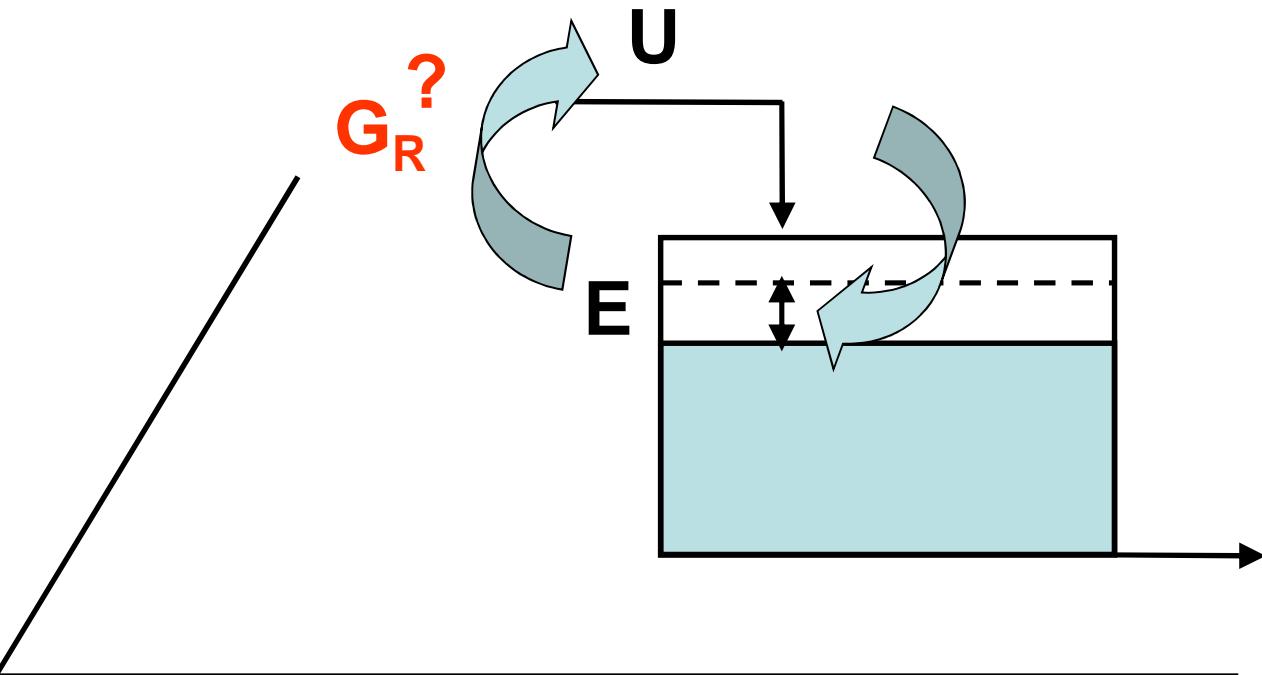


$$\text{TRO: } E(\infty) = W(\infty) - Y(\infty)$$

# Zákon riadenia

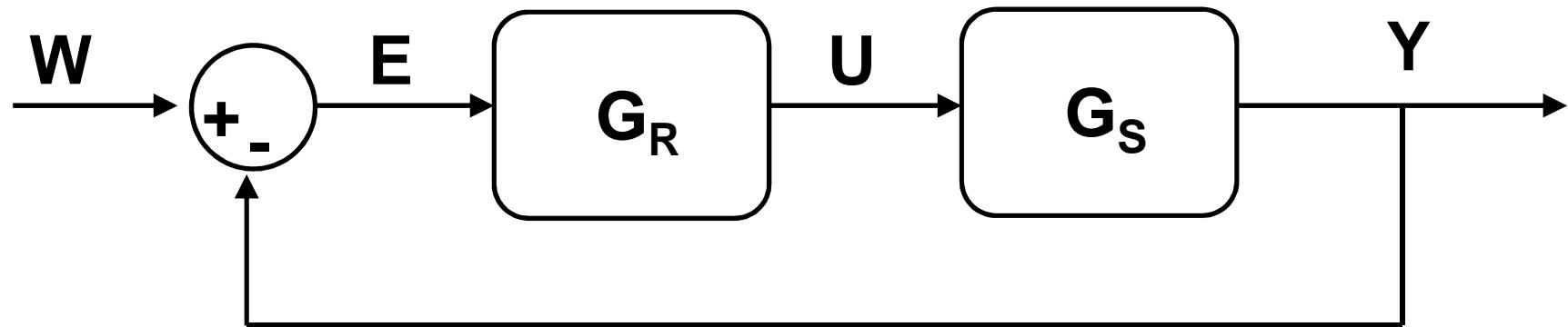


## Zákon riadenia

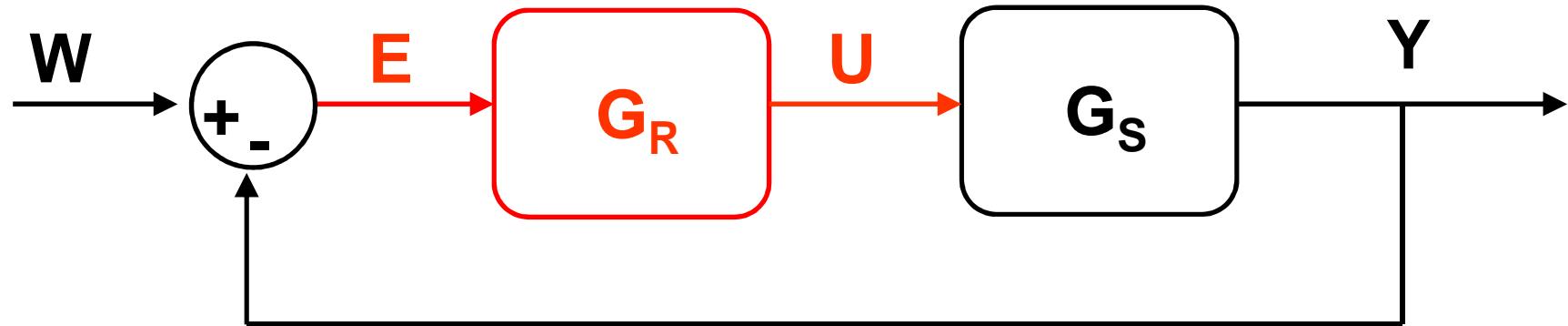


fyzické dynamické zariadenie, ktoré na základe regulačnej odchýlky vypočíta veľkosť akčného zásahu tak, aby výsledná regulačná odchýlka bola čo najmenšia

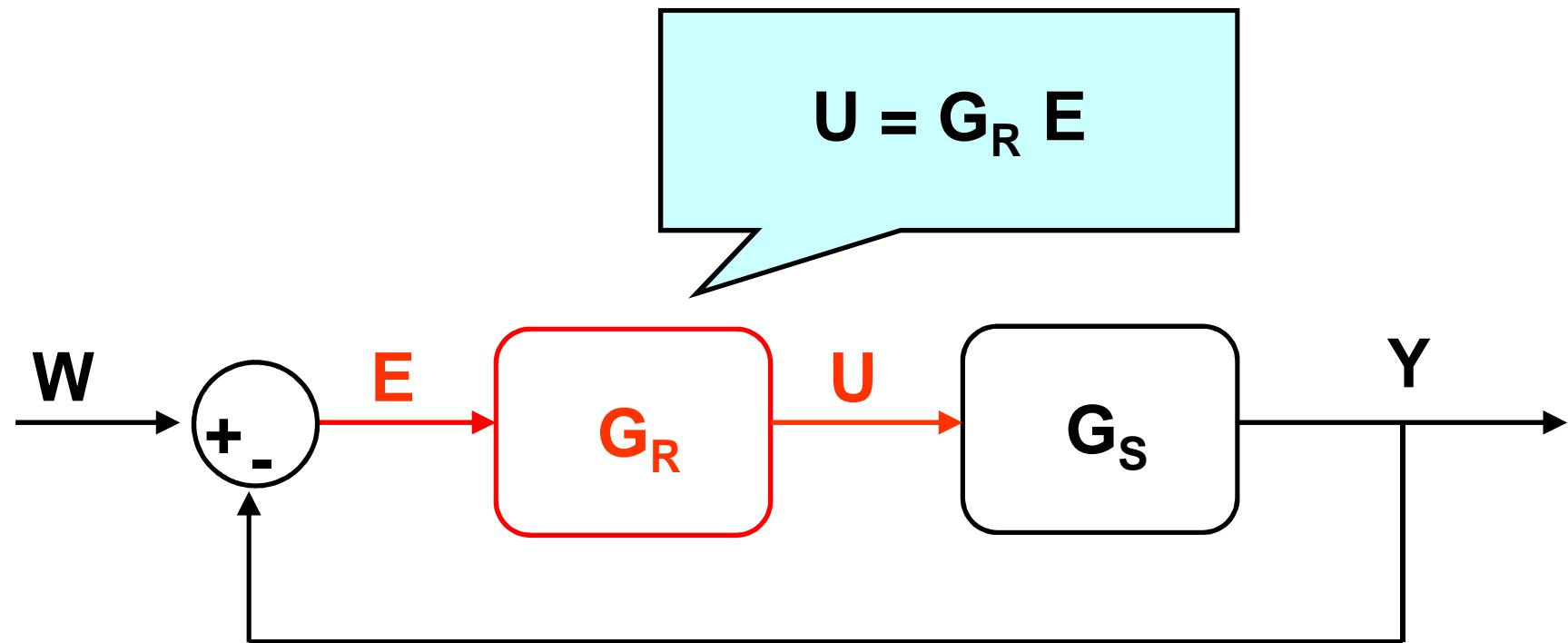
# Zákon riadenia



# Zákon riadenia



# Zákon riadenia



# Zákon riadenia

$$u(t) = G_R e(t)$$

## Zákon riadenia

- Proporcionálny regulátor:

$$u(t) = G_{R,P} e(t)$$

## Zákon riadenia

- Proporcionálny regulátor:

$$u(t) = G_{R,P} e(t)$$

- Prenos:

$$G_{R,P} = Z_R$$

- Zákon riadenia:

$$u(t) = Z_R e(t)$$

## Zákon riadenia

- Proporcionálno-integračný regulátor:

$$u(t) = G_{R,PI} e(t)$$

## Zákon riadenia

- Proporcionálno-integračný regulátor:

$$u(t) = G_{R,PI} e(t)$$

- Prenos: 
$$G_{R,PI} = \frac{Z_R s + \frac{Z_R}{T_I}}{s}$$

- Zákon riadenia:

$$u(t) = Z_R e(t) + \frac{Z_R}{T_I} \int_0^t e(\tau) d\tau$$

## Zákon riadenia

- Proporcionálno-integračný regulátor:

$$u(t) = G_{R,PI} e(t)$$

$$\bullet \text{ Prenos: } G_{R,PI} = \frac{Z_R s + \frac{Z_R}{T_I}}{s}$$

- Zákon riadenia:

$$u(t) = u_P(t) + u_I(t)$$

## Zákon riadenia

- Proporcionálno-integračný regulátor:

$$u(t) = G_{R,PI} e(t)$$

- Prenos: 
$$G_{R,PI} = \frac{Z_R s + \frac{Z_R}{T_I}}{s}$$

- Zákon riadenia:

$$u_I(t) = \frac{Z_R}{T_I} \int_0^t e(\tau) d\tau$$

## Zákon riadenia

- Proporcionálno-integračný regulátor:

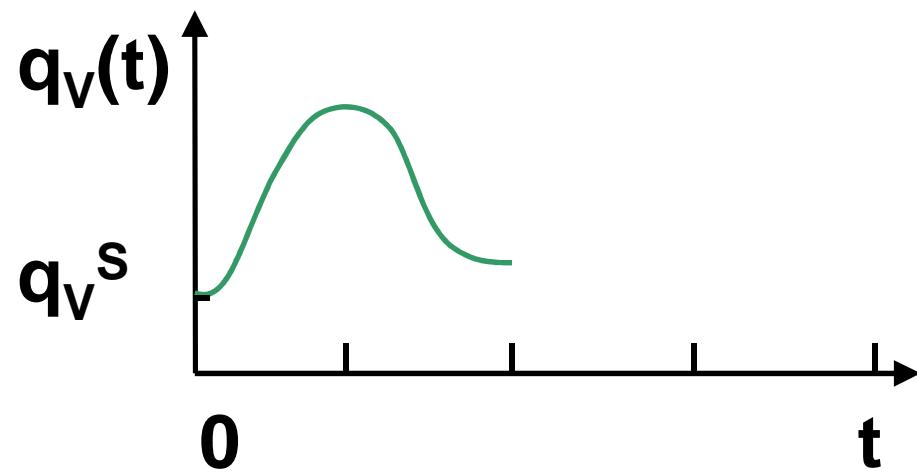
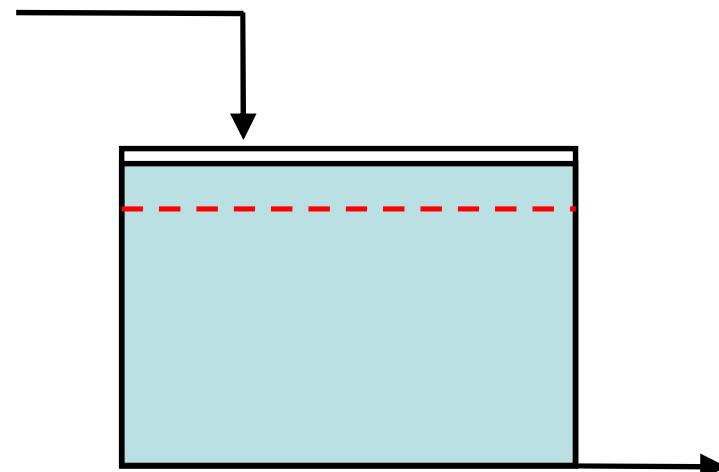
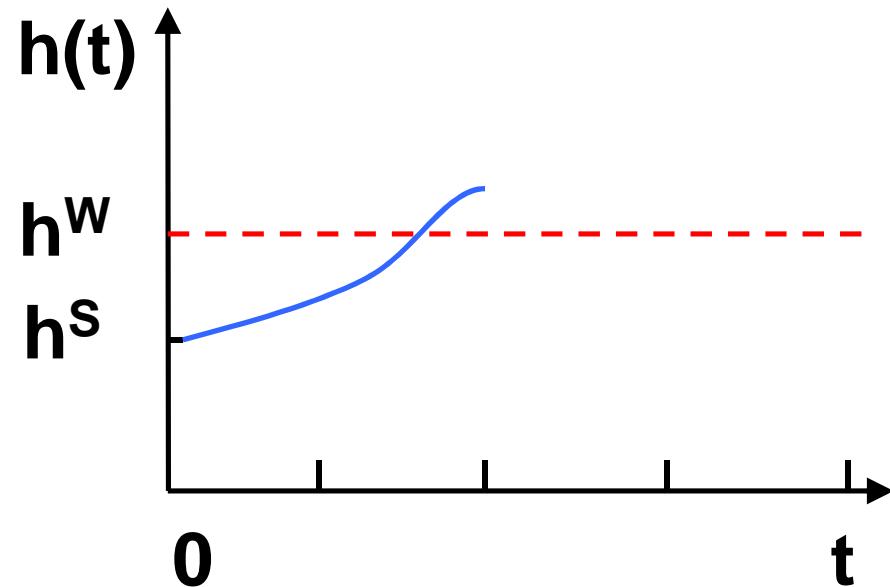
$$u(t) = G_{R,PI} e(t)$$

$$\bullet \text{ Prenos: } G_{R,PI} = \frac{Z_R s + \frac{Z_R}{T_I}}{s}$$

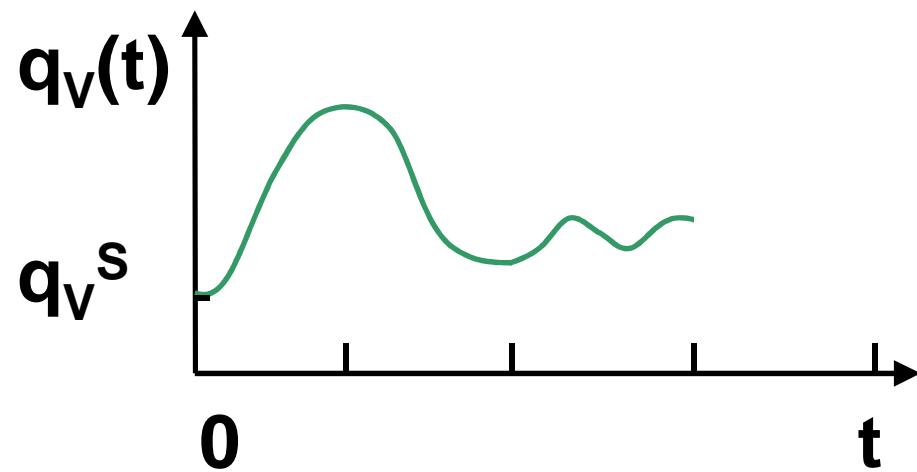
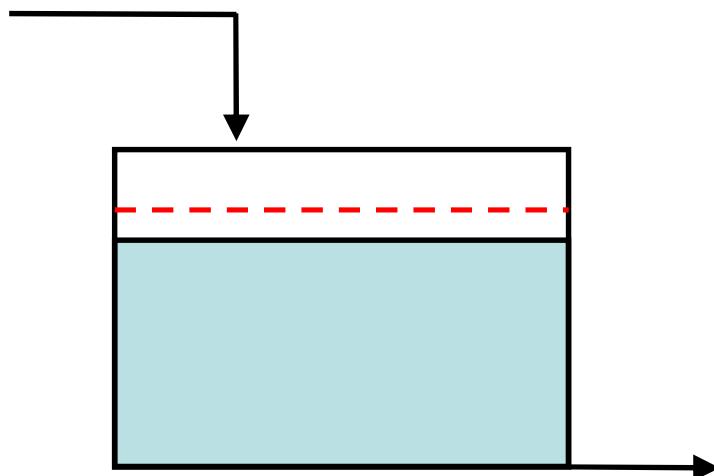
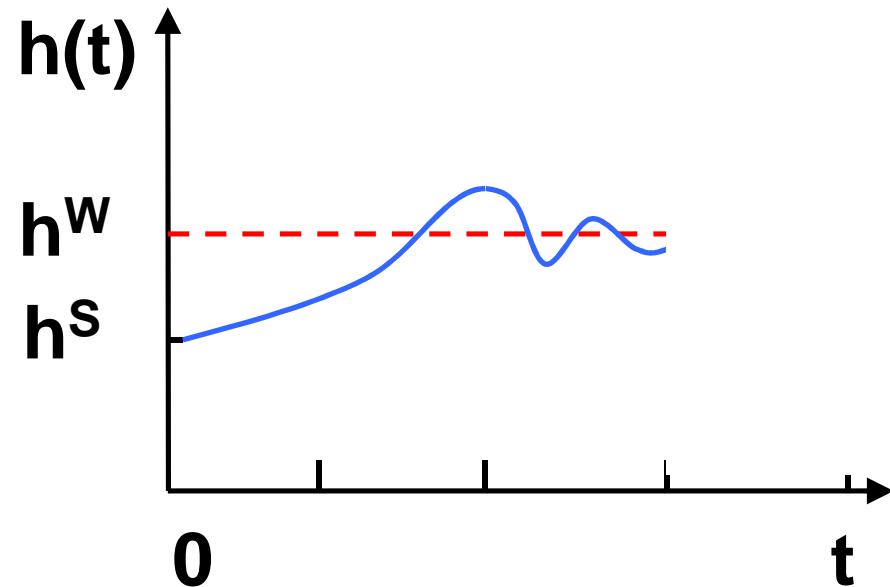
- Zákon riadenia:

$$\frac{du_I(t)}{dt} = \frac{Z_R}{T_I} e(t)$$

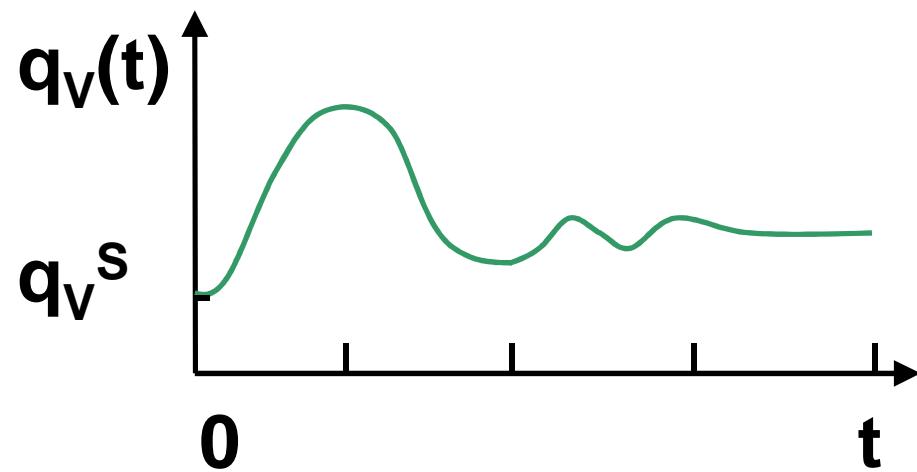
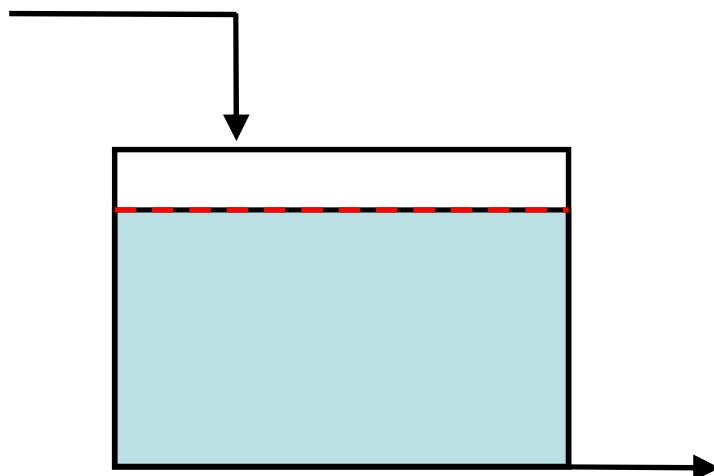
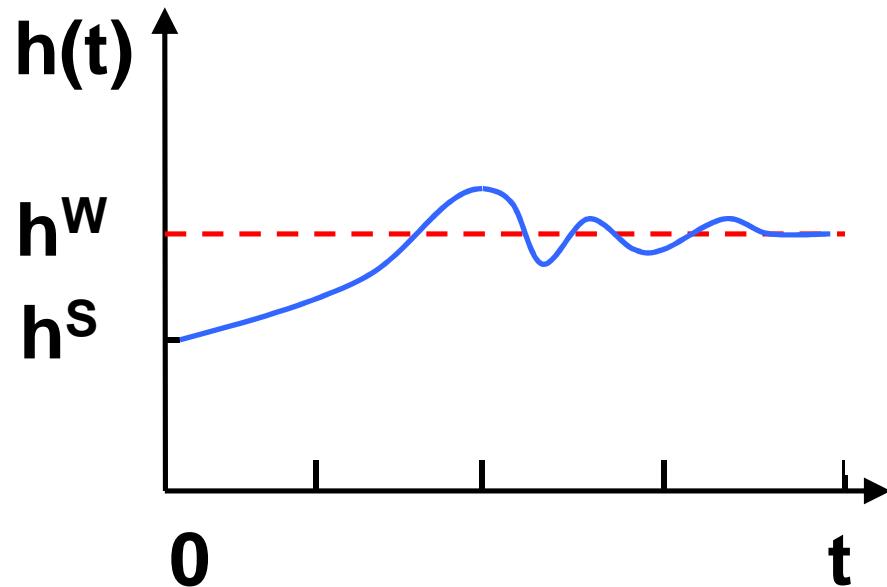
# Zákon riadenia



# Zákon riadenia



# Zákon riadenia



## Zákon riadenia

- Proporcionálno-integračno derivačný regulátor:

$$u(t) = G_{R,PID} e(t)$$

## Zákon riadenia

- Proporcionálno-integračno derivačný regulátor:

$$u(t) = G_{R,PID} e(t)$$

- Prenos:

$$G_{R,PID} = \frac{Z_R s + \frac{Z_R}{T_I} + Z_R T_D s^2}{s}$$

- Zákon riadenia:

$$u(t) = Z_R e(t) + \frac{Z_R}{T_I} \int_0^t e(\tau) d\tau + Z_R T_D \frac{de(t)}{dt}$$

## Zákon riadenia

- Proporcionálno-derivačný regulátor:

$$u(t) = G_{R,PD} e(t)$$

- Prenos:  $G_{R,PD} = \frac{Z_R s + Z_R T_D s^2}{s}$

- Zákon riadenia:

$$u(t) = Z_R e(t) + Z_R T_D \frac{de(t)}{dt}$$

## Zákon riadenia

- Proporcionálno-derivačný regulátor:

$$u(t) = G_{R,PD} e(t)$$

- Prenos:  $G_{R,PD} = Z_R + Z_R T_D s$

- Zákon riadenia:

$$u(t) = Z_R e(t) + Z_R T_D \frac{de(t)}{dt}$$

## Zákon riadenia

- Proporcionálno-derivačný regulátor:

$$u(t) = G_{R,PD} e(t)$$

- Prenos:  $G_{R,PD} = Z_R + Z_R T_D s$

- Zákon riadenia:

$$u(t) = u_P(t) + u_D(t)$$

## Zákon riadenia

- Proporcionálno-derivačný regulátor:

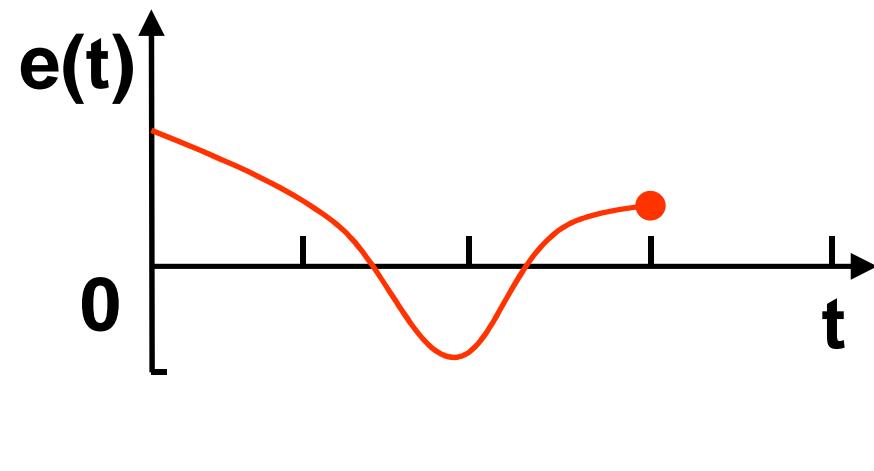
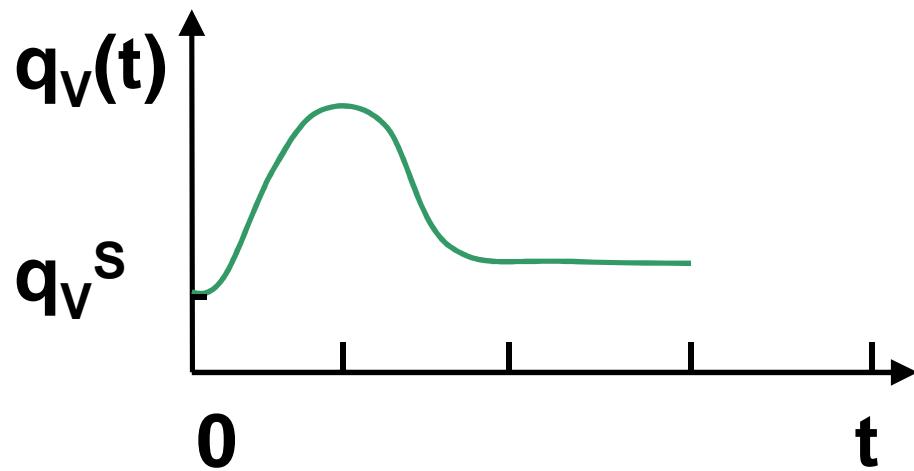
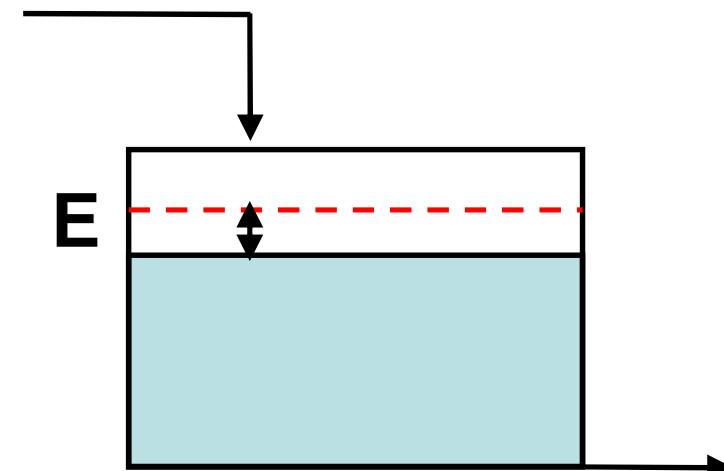
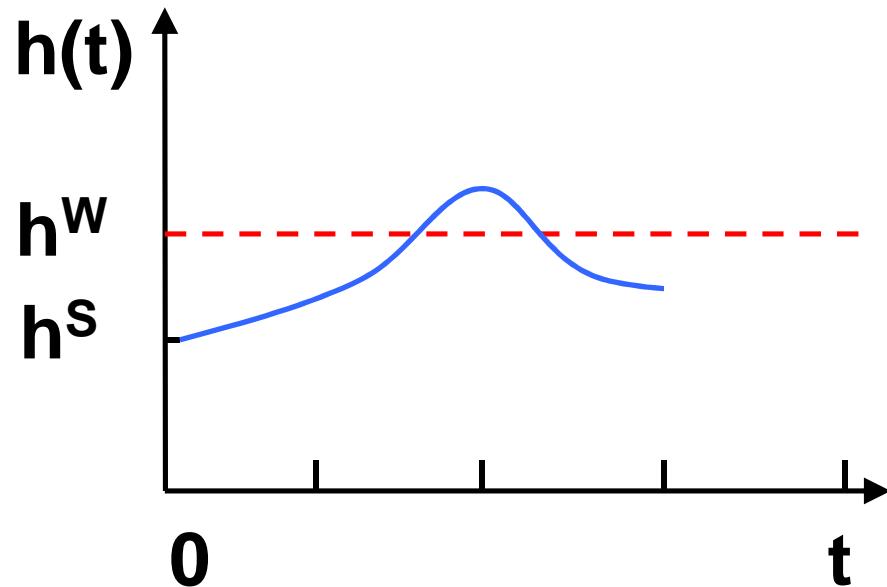
$$u(t) = G_{R,PD} e(t)$$

- Prenos:  $G_{R,PD} = Z_R + Z_R T_D s$

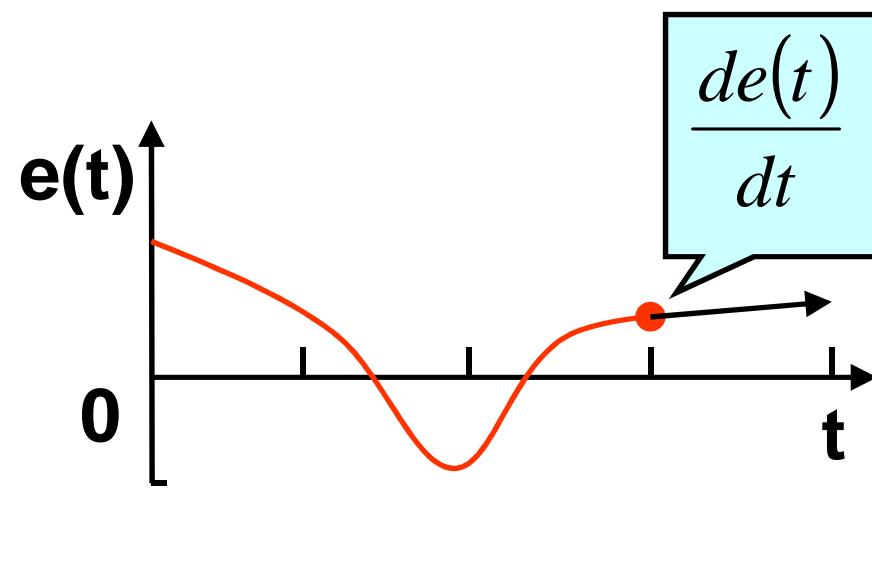
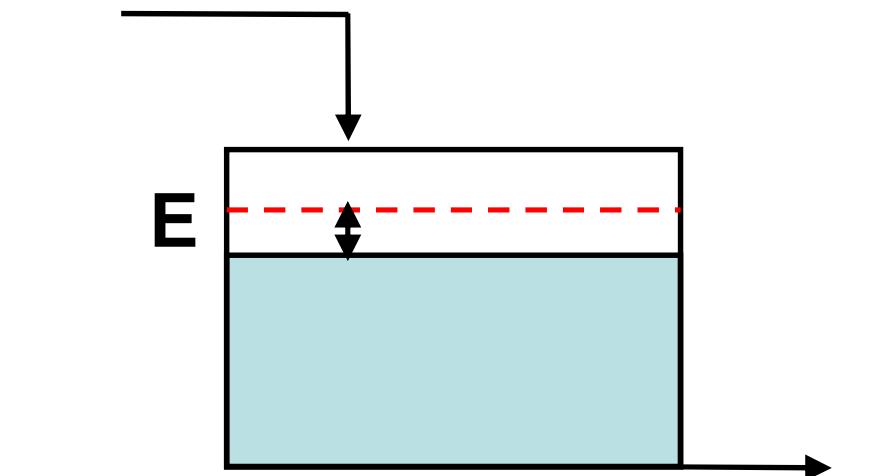
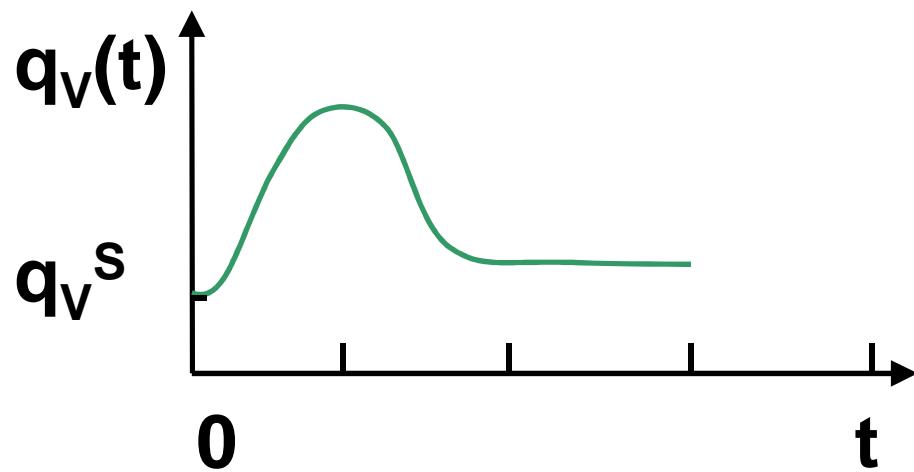
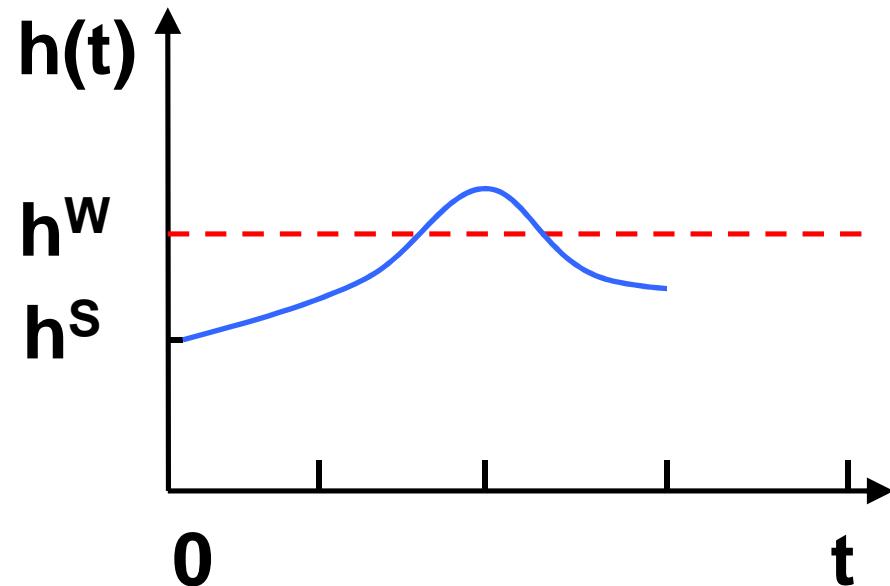
- Zákon riadenia:

$$u_D(t) = Z_R T_D \frac{de(t)}{dt}$$

# Zákon riadenia



# Zákon riadenia



## 7. Zadanie z LCRP – teoretická časť

- URO
- prenos URO
- CHR URO
- zákon riadenia
- Routhovo-Schurovo kritérium stability

## Routhovo-Schurovo kritérium stability

- Systém:

$$G_S = \frac{8}{s^3 + 6s^2 + 11s + 6}$$

- Proporcionálno-integračný regulátor:

$$G_{R,PI} = \frac{4s + \frac{4}{20}}{s}$$

- Charakteristická rovnica:

$$1 + G_R G_S = 0$$

## Routhovo-Schurovo kritérium stability

- Charakteristická rovnica:

$$1 + G_R G_S = 0$$

## Routhovo-Schurovo kritérium stability

- Charakteristická rovnica:

$$s^4 + 6s^3 + 11s^2 + 38s + 1.6 = 0$$

## Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1      6      11      38      1.6    1.) koeficienty CHR

## Routhovo-Schurovo kritérium stability

I.:  $a_4 \quad a_3 \quad a_2 \quad a_1 \quad a_0$  • algoritmus R-S:  
1. 6 11 38 1.6 1.) koeficienty CHR

## Routhovo-Schurovo kritérium stability

I.:  $a_4 = 1$     $\underline{a_3 = 6}$     $a_2 = 11$     $a_1 = \underline{38}$     $a_0 = 1.6$

- algoritmus R-S:

1.) koeficienty CHR

2.) podčiarknúť  
každý druhý

## Routhovo-Schurovo kritérium stability

I.:  $a_4 = 1$     $\underline{a_3 = 6}$     $a_2 = 11$     $a_1 = \underline{38}$     $a_0 = 1.6$

- algoritmus R-S:

- 1.) koeficienty CHR

- 2.) podčiarknúť  
každý druhý

- 3.) parameter  $k_1$

$$k_1 = a_4/a_3 = 1/6$$

## Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1      6      11

38

1.6

1.) koeficienty CHR

2.) podčiarknúť  
každý druhý

3.) parameter  $k_1$

4.) odčítať od  
nepodčiarknutých  
koeficientov  
nasledujúci  
koeficient krát  
parameter  $k_1$

## Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.:    1    6    11    38    1.6    1.) koeficienty CHR

$$1-6 \cdot 1/6 = 0$$

II.:    0

2.) podčiarknúť  
každý druhý

3.) parameter  $k_1$

4.) odčítať od  
nepodčiarknutých  
koeficientov  
nasledujúci  
koeficient krát  
parameter  $k_1$

## Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1      6      11      38      1.6    1.) koeficienty CHR

II.: 0      6

2.) podčiarknúť  
každý druhý

3.) parameter  $k_1$

4.) odčítať od  
nepodčiarknutých  
koeficientov  
nasledujúci  
koeficient krát  
parameter  $k_1$

## Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1      6      11      38      1.6      1.) koeficienty CHR

                        11-38\*1/6      2.) podčiarknúť

II.: 0      6      28/6      každý druhý

3.) parameter  $k_1$

4.) odčítať od  
nepodčiarknutých  
koeficientov  
nasledujúci  
koeficient krát  
parameter  $k_1$

## Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1      6      11

38

1.6

1.) koeficienty CHR

II.: 0      6      28/6

38

2.) podčiarknúť  
každý druhý

3.) parameter  $k_1$

4.) odčítať od  
nepodčiarknutých  
koeficientov  
nasledujúci  
koeficient krát  
parameter  $k_1$

## Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1      6      11      38      **1.6**      1.) koeficienty CHR

II.: 0      6      28/6      38      **1.6**      2.) podčiarknúť  
každý druhý

III.:                               3.) parameter  $k_1$   
IV.:                               4.) odčítať od  
nepodčiarknutých  
koeficientov  
nasledujúci  
koeficient krát  
parameter  $k_1$

## Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1      6      11      38      1.6      1.) koeficienty CHR

2.) podčiarknúť  
každý druhý

II.: 0      6      28/6      38      1.6      3.) parameter  $k_1$

4.) použiť  $k_1$

5.) otestovať, či sú  
koeficienty kladné

# Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1 6 11 38 1.6 1.) koeficienty CHR

II. 0 ✓ 6 ✓ 28/6 ✓ 38 ✓ 1 ✓ 6 ✓ 2.) podčiarknúť každý druhý

II.: 0 6 28/6 38 1.6 Kazdy druhý  
3.) parameter  $k_1$

## 4.) použit' k<sub>1</sub>

5.) otestovať, či sú koeficienty kladné

## Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.:    1       6       11       38       1.6    1.) koeficienty CHR

II.:       $a_3$        $a_2$        $a_1$        $a_0$     2.) podčiarknúť  
              6          28/6     38       1.6    každý druhý

3.) parameter  $k_1$

4.) použiť  $k_1$

5.) otestovať koef.

6.) otestovať rám  
polynómu

# Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1 6 11 38 1.6 1.) koeficienty CHR

$$\text{II. } \begin{array}{cccccc} & a_3 & a_2 & a_1 & a_0 & 2.) \text{ podčiarknúť} \\ \text{III. } & 6 & 28/6 & 28 & 1/6 & \text{každý druhý} \end{array}$$

II.: 6 28/6 38 1.6 Kazdy druhý  
□ 3.) parameter  $k_1$

4.) použit' k<sub>1</sub>

5.) otestovat' koef.

## 6.) otestovať rád polynómu

$$6s^3 + 4.7s^2 + 38s + 1.6 = 0$$

# Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1 6 11 38 1.6 1.) koeficienty CHR

$a_3$	$a_2$	$a_1$	$a_0$	2.) podčiarknúť každý druhý
6	28/6	28	1/6	

II.: 6 28/6 38 1.6 Kazdy druh  
□ 3.) parameter  $k_1$

A large, light blue downward-pointing arrow, indicating the direction of the following text.

$$6s^3 + 4.7s^2 + 38s + 1.6 = 0$$

$$\dim\{p_{II}(s)\}=3>2$$

2.) podčiarknúť  
každý druhý

### 3.) parameter $k_1$

## 4.) použit' k<sub>1</sub>

5.) otestovat' koef.

## 6.) otestovať rád polynómu

# Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1 6 11 38 1.6 1.) koeficienty CHR

2.) podčiarknúť  
každý druhý

II.: 6 28/6 38 1.6 Kazdy druhý

3.) parameter  $k_1$

## 4.) použit' k<sub>1</sub>

5.) otestovat' koef.

6.) otestovať rád

## 7.) spät' na krok 2.)

# Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1 6 11 38 1.6 1.) koeficienty CHR

## 2.) podčiarknúť každý druhý

II.: 6 28/6 38 1.6 **Razdy Gran**  
3.) parameter  $k_1$

## 4.) použit' k<sub>1</sub>

## 5.) otestovat' koef.

6.) otestovat' rád

7.) spät' na krok 2.)

# Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1 6 11 38 1.6 1.) koeficienty CHR

## 2.) podčiarknúť každý druhý

II.: 6 28/6 38 1.6 Razy drury  
3.) parameter  $k_1$

## 4.) použit' k<sub>1</sub>

## 5.) otestovat' koef.

6.) otestovat' rád

7.) spät' na krok 2.)

## Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1      6      11      38      1.6      1.) koeficienty CHR

II.:                 $a_3$        $a_2$        $a_1$        $a_0$       2.) podčiarknúť  
              6      28/6      38      1.6      každý druhý

3.) parameter  $k_2$

4.) použiť  $k_1$

5.) otestovať koef.

6.) otestovať rád

7.) späť na krok 2.)

## Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1      6      11      38      1.6      1.) koeficienty CHR

II.:                 $a_3$        $a_2$        $a_1$        $a_0$       2.) podčiarknúť  
              6      28/6      38      1.6      každý druhý

$$k_2 = a_3/a_2 \quad 3.) \text{ parameter } k_2$$

4.) použiť  $k_1$

5.) otestovať koef.

6.) otestovať rád

7.) späť na krok 2.)

## Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.:    1       6       11       38       1.6    1.) koeficienty CHR

II.:       $a_3$        $a_2$        $a_1$        $a_0$     2.) podčiarknúť  
              6          28/6    38          1.6      každý druhý

$$k_2 = 6/(28/6)$$

3.) parameter  $k_2$

4.) použiť  $k_1$

5.) otestovať koef.

6.) otestovať rád

7.) späť na krok 2.)

# Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1 6 11 38 1.6 1.) koeficienty CHR

2.) podčiarknúť  
každý druhý

II.: 6 28/6 38 1.6

3.) parameter  $k_2$

$$6 - \frac{28}{6} * \frac{36}{28} = 0$$

## 4.) použit' k<sub>2</sub>

0

5.) otestovat' koef.

## 6.) otestovať rád

7.) spät' na krok 2.)

# Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1 6 11 38 1.6 1.) koeficienty CHR

2.) podčiarknúť  
každý druhý

II.: 6 28/6 38 1.6 Kazdy druhý

### 3.) parameter k,

0 28/6 +.) použít  $R_2$

## 5.) otestovat' koef.

## 6.) otestovat' rád

7.) spät' na krok 2.)

# Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1 6 11 38 1.6 1.) koeficienty CHR

2.) podčiarknúť  
každý druhý

II.: 6 28/6 38 1.6

3.) parameter k,

III.: 0 4.7 1258/35

## 4.) použit' k<sub>2</sub>

0 4.7 1258/35

## 5.) otestovat' koef.

6.) otestovať rád

7.) spät' na krok 2.)

# Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1 6 11 38 1.6 1.) koeficienty CHR

2.) podčiarknúť  
každý druhý

II.: 6 28/6 38 1.6 Kazdy druhý  
3.) parameter  $k_2$

### 3.) parameter $k_2$

III.: 0 4.7 35.9 1.6 4.) použít  $R_2$   
5.) otestovat' koef.

4.) použit  $\kappa_2$

## 5.) otestovat' koef.

6.) otestovat' rád

7.) spät' na krok 2.)

# Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1 6 11 38 1.6 1.) koeficienty CHR

2.) podčiarknúť  
každý druhý

II.: 6 28/6 38 1.6 Kazdy druhý  
3.) parameter  $k_2$

### 3.) parameter $k_2$

III.: 0 4.7 35.9 1.6 4.) použit' k<sub>2</sub>  
5.) otestovat' koef.

4.) použit' k<sub>2</sub>

## 5.) otestovat' koef.

6.) otestovať rád

## 7.) spät' na krok 2.)

# Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1 6 11 38 1.6 1.) koeficienty CHR

2.) podčiarknúť  
každý druhý

II.: 6 28/6 38 1.6 Kazdy druhý

### 3.) parameter k,

III.: 0 4.7 35.9 1.6 4.) použit  $\kappa_2$

5.) otestovat' koef.

6.) otestovať rád

7.) spät' na krok 2.)

# Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1 6 11 38 1.6 1.) koeficienty CHR

2.) podčiarknúť  
každý druhý

II.: 6 28/6 38 1.6 Kazdy druh  
3.) parameter k,

3.) parameter  $k_2$

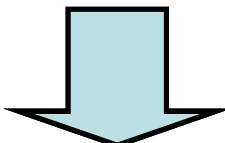
$$\text{III.: } \begin{array}{ccc} a_2 & a_1 & a_0 \\ 4.7 & 35.9 & 1.6 \end{array} \quad 4.) \text{ použit' k}_2$$

4.) použit' k<sub>2</sub>

5.) otestovat' koef.

## 6.) otestovať rád

## 7.) spät' na krok 2.)



$$4.7s^2 + 35.9s + 1.6 = 0$$

# Routhovo-Schurovo kritérium stability

- algoritmus R-S:

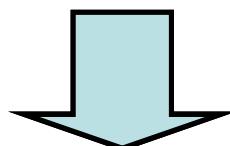
I.: 1 6 11 38 1.6 1.) koeficienty CHR

II.: 6 28/6 38 1.6 Kazdy druhý

3.) parameter  $k_2$

$a_2 \quad a_1 \quad a_0$  → použít k

III.: 4.7 35.9 1.6 4.) použit  $k_2$



$$\dim\{p_{III}(s)\}=2$$

5.) otestovat koef.

## 6.) otestovať rád

7.) spät' na krok 2.)

# Routhovo-Schurovo kritérium stability

- algoritmus R-S:

I.: 1 6 11 38 1.6 1.) koeficienty CHR

2.) podčiarknúť  
každý druhý

3.) parameter k,

## 4.) použit' k<sub>2</sub>

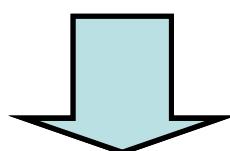
5.) otestovat' koef.

6.) otestovať rád

## 7.) koniec – stabilné

II.: 6 28/6 38 1.6

$$\begin{array}{ccc} a_2 & a_1 & a_0 \\ 4.7 & 35.9 & 1.6 \end{array}$$



$$\dim\{p_{III}(s)\}=2$$

## Routhovo-Schurovo kritérium stability

- algoritmus R-S:

- 1.)  $i = 0$ , určiť koeficienty CHR
- 2.)  $i := i + 1$ , podčiarknúť každý druhý koeficient
- 3.) parameter  $k_i = a_n / a_{n-1}$
- 4.) odčítať od nepodčiarknutých koeficientov nasledujúci koeficient krát parameter  $k_i$
- 5.) otestovať koeficienty  $p_i(s) > 0$
- 6.) otestovať rád:  
ak  $\dim\{p_i(s)\} > 2$  chod' na krok 2.) inak Koniec