

# OTOMATİK KONTROL

MİLLİ SAVUNMA ÜNİVERSİTESİ

KARA HARP OKULU

ELEKTRONİK ve HABERLEŞME MÜHENDİSLİĞİ

# **BLOK DİYAGRAMLARI ve SADELEŞTİRİLMESİ**

# BLOK DİYAGRAMLARI

Karmaşık sistemler bir çok alt sistemin bir araya gelmesiyle oluşmuştur.

Eğer karmaşık bir sistemi tek bir transfer fonksiyonuna veya alt sisteme indirgeyebilirsek tüm sistemi analitik olarak daha kolay inceleyebiliriz.

Karmaşık sistemleri tek bir transfer fonksiyonuna iki yöntemle indirgeyebiliriz:

1. Blok Diyagramları
2. İşaret Akış Diyagramları

# BLOK DİYAGRAMLARI

Kontrol sistemlerini meydana getiren elemanların görevlerini göstermek için blok diyagramlar kullanılır.

Bir sistemin blok diyagramı sistem parçalarının fonksiyonlarının ve sinyal akışının şekilsel gösterimidir.

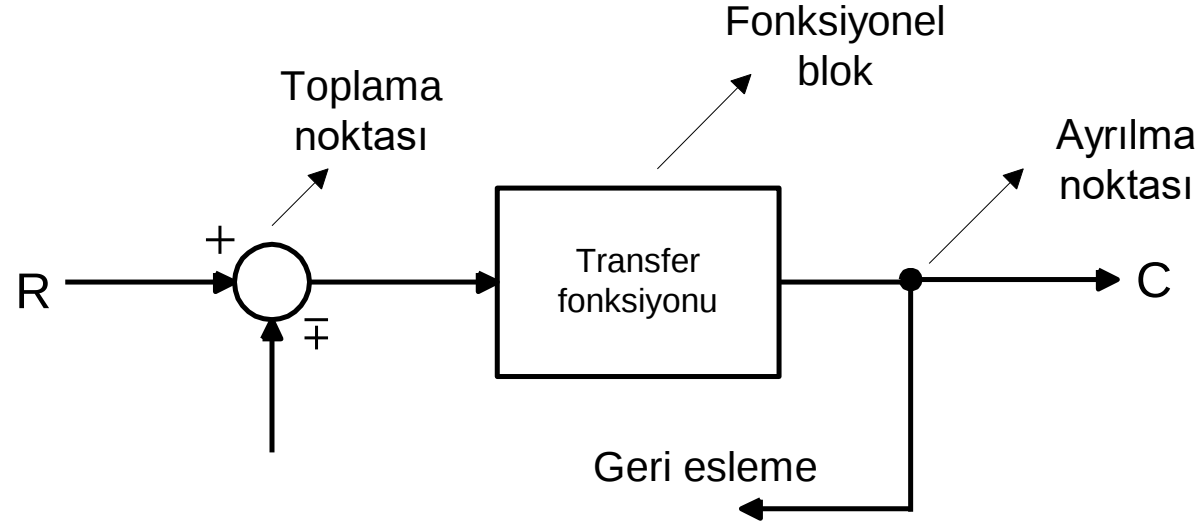
Bir blok diyagramı;

- **fonksiyonel bloklar** (sadece blok olarak da adlandırılır),
- **toplama noktaları** ve
- **ayırılma noktalarından** meydana gelir.
- Sinyal akışları oklar ile gösterilirler.

# BLOK DİYAGRAMININ ÖZELLİKLERİ

1. Blok diyagramı gerçek sistemin sinyal akışlarını gösterir. Bu nedenle sistemin soyut matematiksel gösterimine göre sistemi daha gerçekçi bir şekilde temsil eder.
2. Bir blok diyagram sistemin dinamik davranışı ile ilgili bilgiyi içermekte olup sistemin fiziksel yapısı ile ilgili herhangi bir bilgi vermez.
3. Blok diyagram üzerinde enerjinin esas kaynağı açık bir şekilde gösterilmez.
4. Verilen sistemin blok diyagramı tek tip değildir. Ele alınan çözümlerin bakış açısına bağlı olarak bir sistem için farklı sayıda blok diyagramı çizilebilir.

# BLOK DİYAGRAMLARI



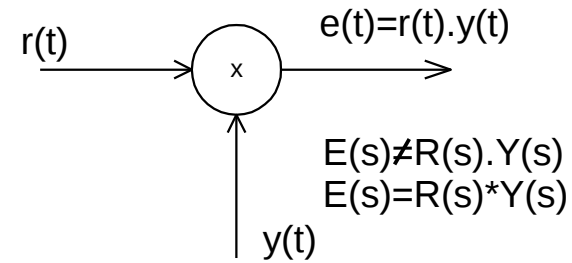
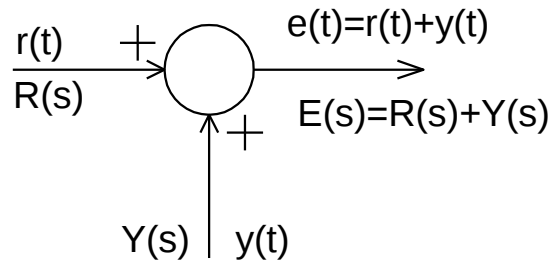
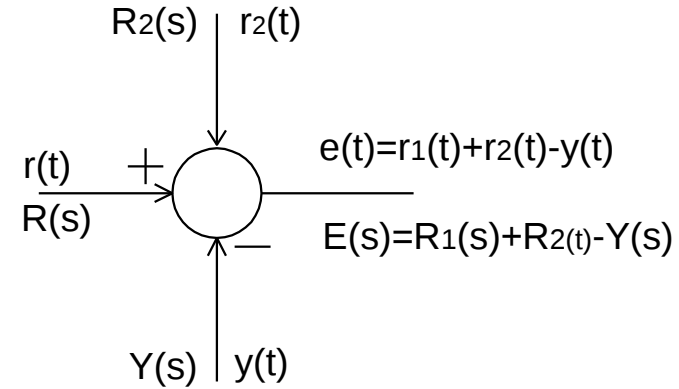
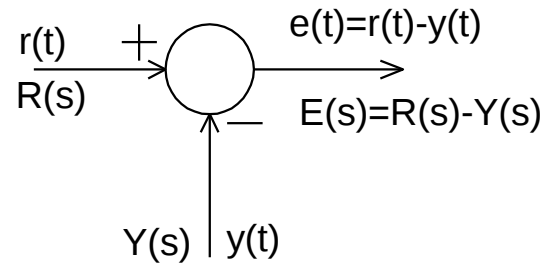
Blok diyagramdaki elemanların gösterilişi

**Fonksiyonel Blok:** Sistemin veya sistemi oluşturan herhangi bir elemanın giriş ve çıkış değişkenleri arasındaki bağlantıyı gösteren bir semboldür.

**Toplama Noktaları:** Toplama işlemini belirtir ve içine çapraz işareti konmuş bir daire veya içi boş bir daire ile gösterilir.

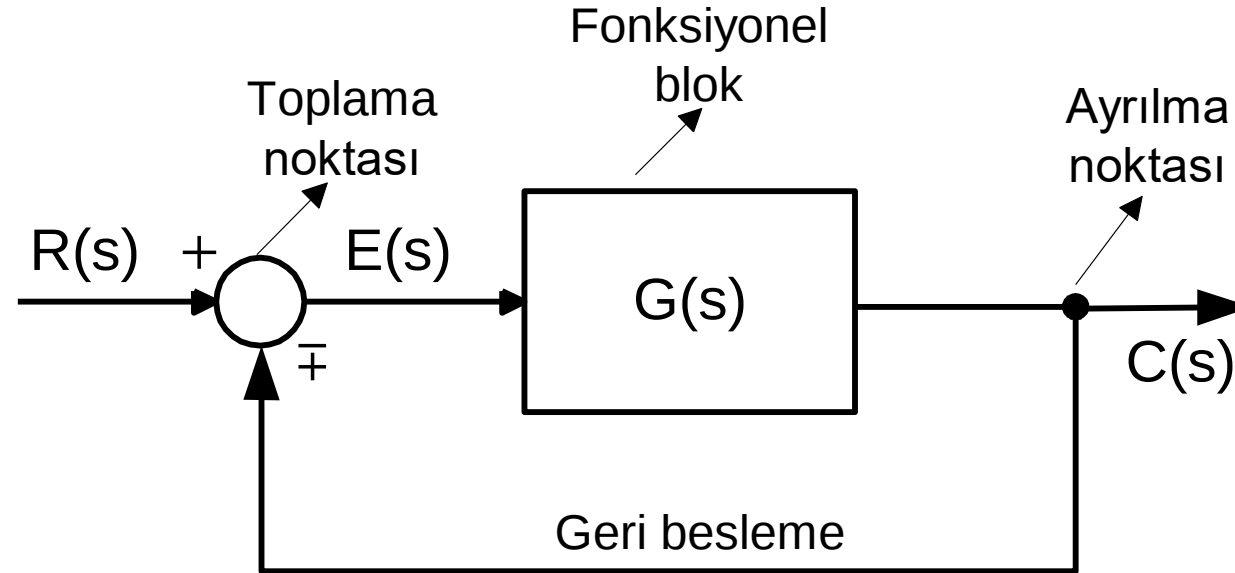
**Ayrılma Noktaları:** Sinyalin veya sinyallerin bir bloktan başka bir bloğa veya toplama noktasına ayrıldığı noktalardır.

# BLOK DİYAGRAMLARI

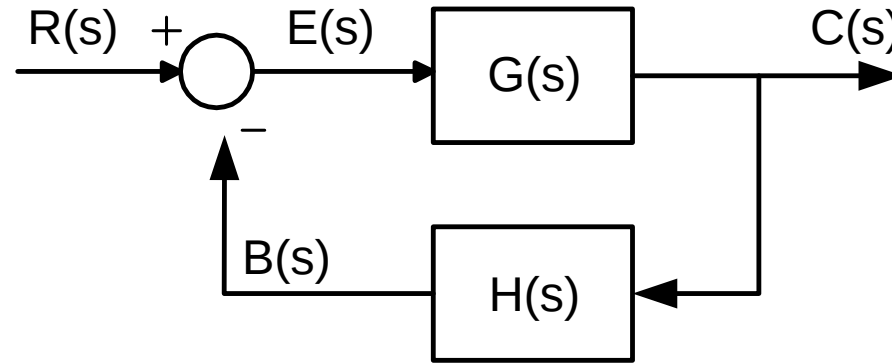


Toplama ve ayrılma noktalarının gösterilişi

# KAPALI ÇEVİRİM SİSTEMİN BLOK DİYAGRAMI



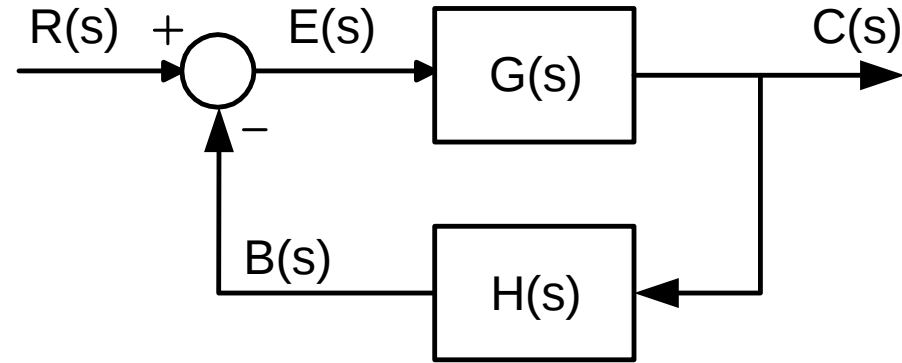
# AÇIK ÇEVİRİM VE İLERİ BESLEME TRANSFER FONKSİYONLARI



$$\text{Açık Çevrim Transfer Fonksiyonu} = \frac{B(s)}{E(s)} = G(s)H(s)$$

$$\text{İleri Yol Transfer Fonksiyonu} = \frac{C(s)}{E(s)} = G(s)$$

# KAPALI ÇEVİRİM TRANSFER FONKSİYONU



**$R(s)$ :** referans giriş

**$C(s)$ :** çıkış (kontrol edilen değişken)

**$B(s)$ :** geri besleme sinyali

**$E(s)$ :** etkin hata

**$H(s)$ :** geri besleme transfer fonksiyonu

**$G(s).H(s)$ :** açık çevrim transfer fonksiyonu

**$G(s)$ :** ileri yol transfer fonksiyonu

**$M(s)$ :**  $C(s) / R(s)$  kapalı çevrim ya da sistem transfer fonksiyonu

# KAPALI ÇEVİRİM TRANSFER FONKSİYONU

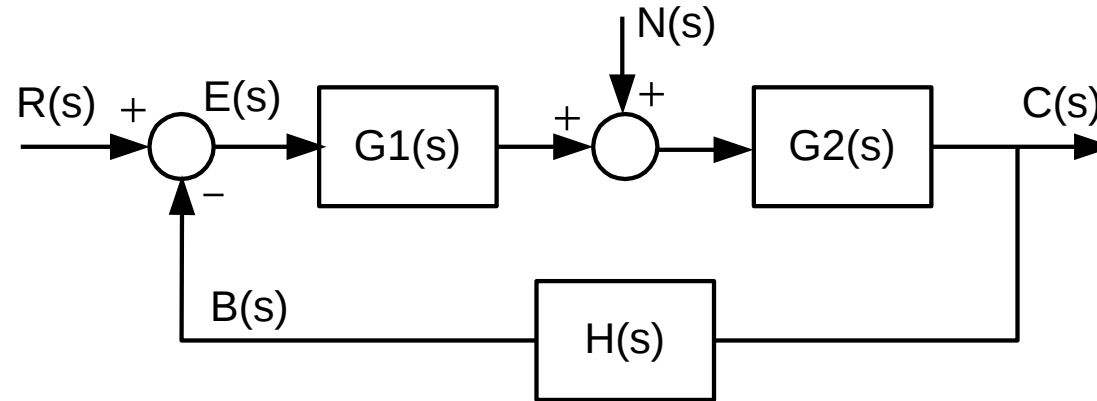
Çıkış  $C(s)$  ile giriş  $R(s)$  aşağıdaki gibi ilişkilendirilir;

$$\begin{aligned}C(s) &= G(s) \cdot E(s) \\E(s) &= R(s) - B(s) \\B(s) &= C(s) \cdot H(s) \\C(s) &= G(s) \cdot [R(s) - C(s) \cdot H(s)] \\C(s) \cdot (1 + G(s) \cdot H(s)) &= G(s) \cdot R(s)\end{aligned}$$

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

$$\text{Transfer fonksiyonu} \Rightarrow M(s) = \frac{C(s)}{R(s)} = \frac{G(s)}{1 + G(s)H(s)}$$

# BOZUCU SİNYAL İÇEREN KAPALI ÇEVİRİM KONTROL SİSTEMİ



$$C(s) = G_2(s) \cdot [N(s) + G_1(s) \cdot E(s)]$$

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

$$B(s) = C(s) \cdot H(s)$$

$$C(s) = G_2(s) \cdot N(s) + G_1(s) \cdot G_2(s) \cdot R(s) - G_1(s) \cdot G_2(s) \cdot C(s) \cdot H(s)$$

$$C(s) \cdot [1 + G_1(s) \cdot G_2(s) \cdot H(s)] = G_1(s) \cdot G_2(s) \cdot R(s) + G_1(s) \cdot N(s)$$

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

# BOZUCU SİNYAL İÇEREN KAPALI ÇEVİRİM KONTROL SİSTEMİ

$$\frac{C_R(s)}{R(s)} = \frac{G_1(s).G_2(s)}{1 + G_1(s).G_2(s).H(s)}$$

Referans girişine bağlı transfer fonksiyonu,

**Eğer  $G_1(s) \cdot G_2(s) \cdot H(s) \gg 1$  olursa;**

$$\frac{C_R(s)}{R(s)} = \frac{G_1(s).G_2(s)}{1 + G_1(s).G_2(s).H(s)} \cong \frac{G_1(s).G_2(s)}{G_1(s).G_2(s).H(s)} \cong \frac{1}{H(s)}$$

$$\frac{C_N(s)}{N(s)} = \frac{G_2(s)}{1 + G_1(s).G_2(s).H(s)}$$

Bozucu girişe bağlı transfer fonksiyonu olarak ifade edilir.

**Eğer  $G_1(s).H(s) \gg 1$  olursa;**

$$\frac{C_N(s)}{N(s)} = \frac{G_2(s)}{1 + G_1(s).G_2(s).H(s)} \cong \frac{G_2(s)}{G_1(s).G_2(s).H(s)} \cong \frac{1}{G_1(s).H(s)}$$

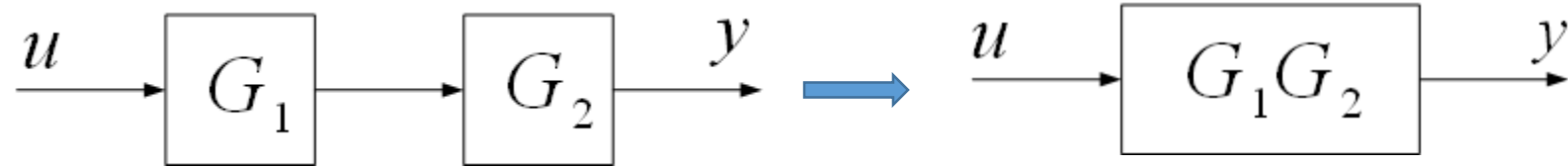
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ

Blok diyagramlar sadeleştirilirken aşağıdaki hususlara dikkat edilmelidir;

- İleri yol yönündeki transfer fonksiyonlarının çarpımları aynı kalmalıdır.
- Çevrim etrafındaki transfer fonksiyonlarının çarpımları aynı kalmalıdır.

# BLOK DİYAGRAMLARIN SADELEŞTİRİLME KURALLARI

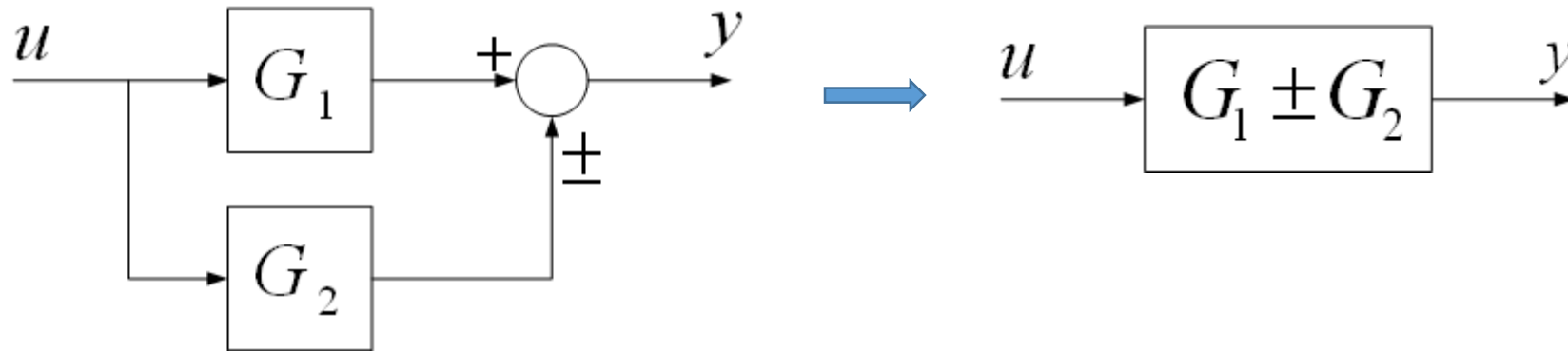
Ardışık(kaskat) bağlantı:



$$y = G_1G_2u$$

# BLOK DİYAGRAMLARIN SADELEŞTİRİLME KURALLARI

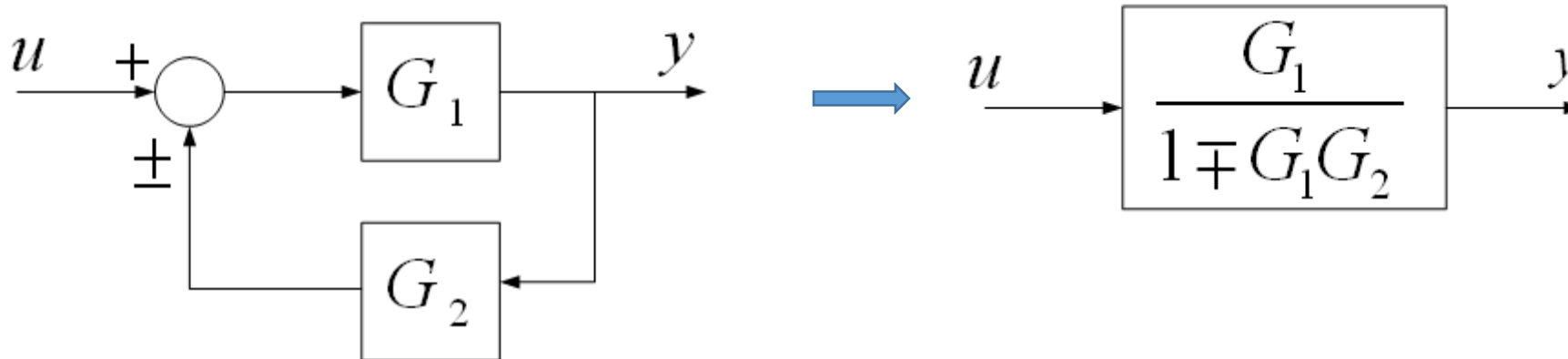
Paralel bağlantı:



$$y = (G_1 \pm G_2)u$$

# BLOK DİYAGRAMLARIN SADELEŞTİRİLME KURALLARI

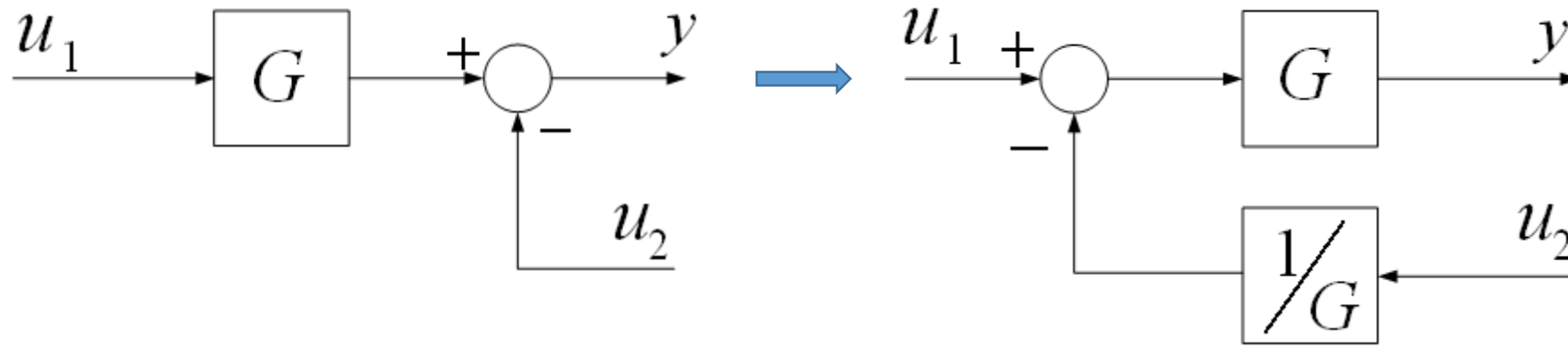
Geri beslemeli bağlantı:



$$y = G_1 (u \pm G_2 y)$$

# BLOK DİYAGRAMLARIN SADELEŞTİRİLME KURALLARI

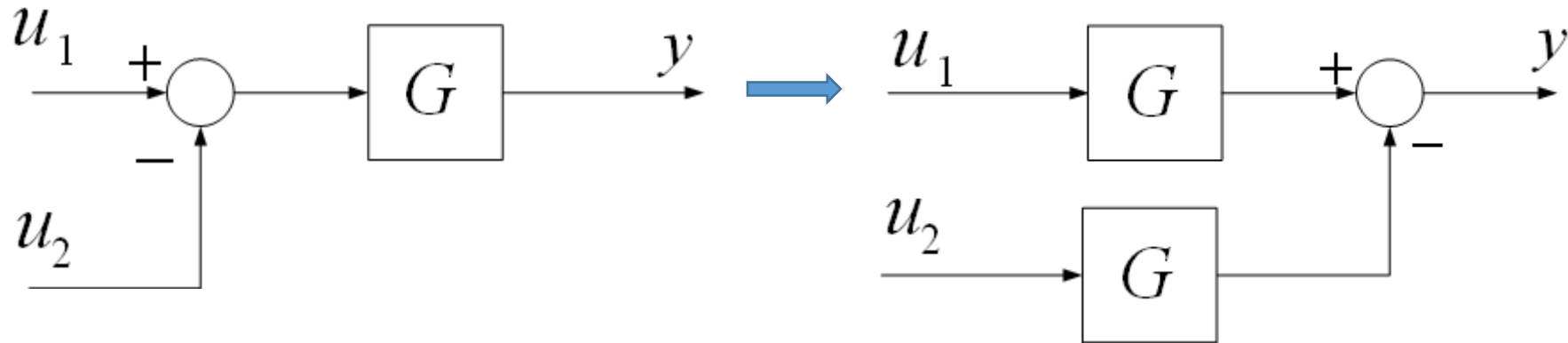
Toplama noktasının bloğun önüne (girişe doğru) kaydırılması:



$$y = Gu_1 - u_2$$

# BLOK DİYAGRAMLARIN SADELEŞTİRİLME KURALLARI

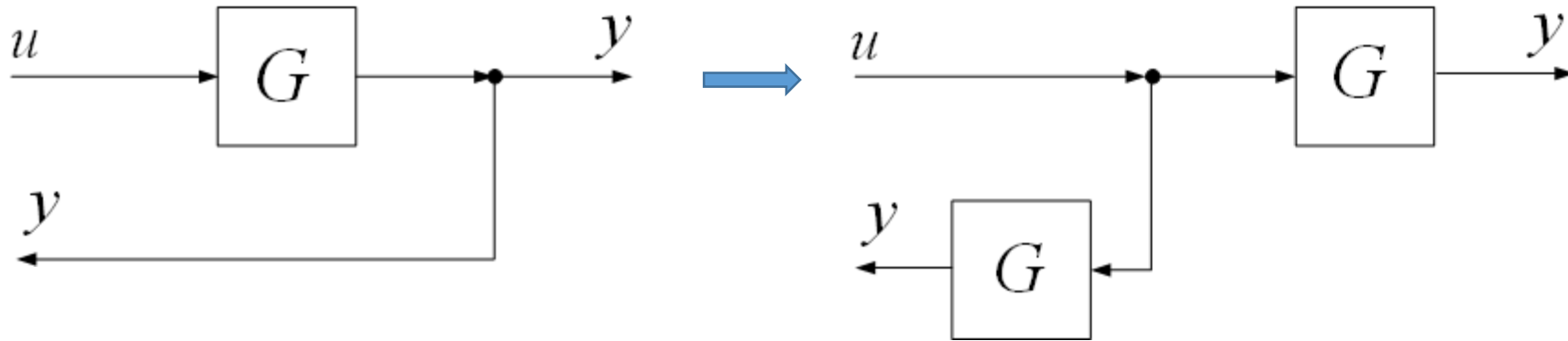
Toplama noktasının bloğun arkasına (çıkışa doğru) kaydırılması:



$$y = G(u_1 - u_2)$$

# BLOK DİYAGRAMLARIN SADELEŞTİRİLME KURALLARI

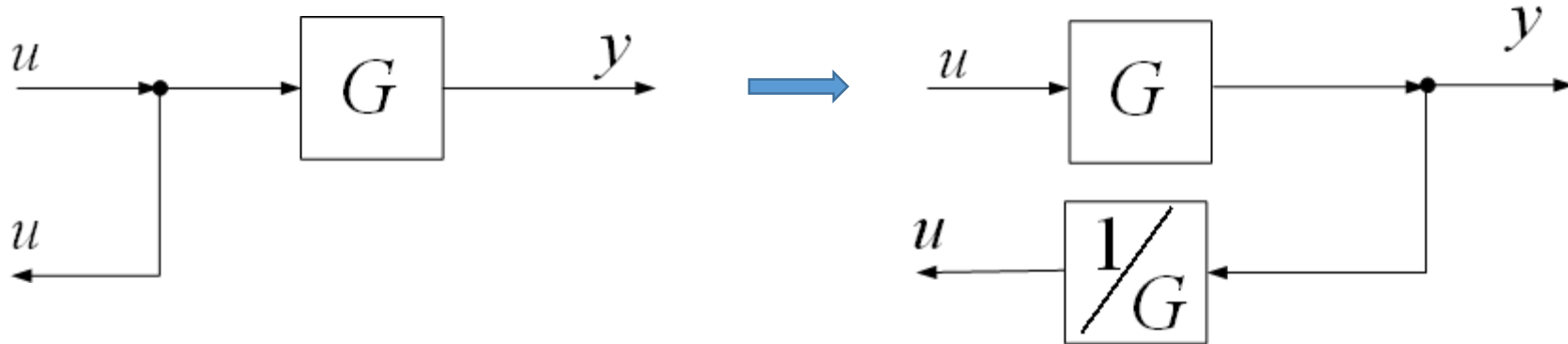
Ayrılma noktasının bloğun önüne (girişe doğru) kaydırılması:



$$y = Gu$$

# BLOK DİYAGRAMLARIN SADELEŞTİRİLME KURALLARI

Ayrılma noktasının bloğun arkasına (çıkışa doğru) kaydırılması:

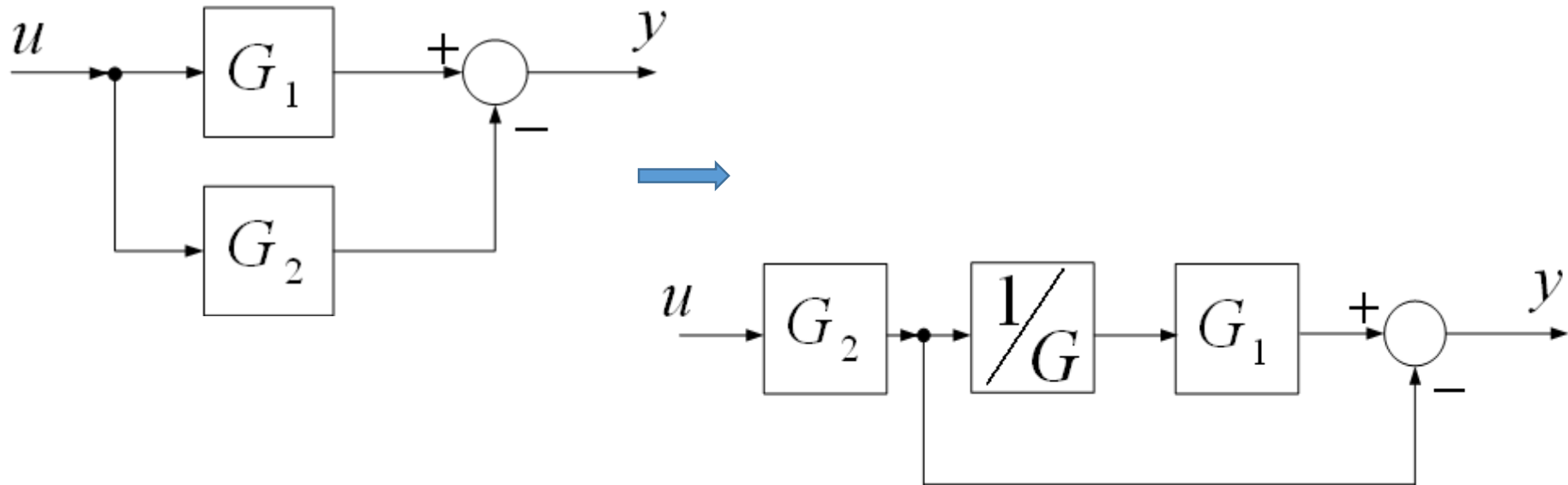


$$y = Gu$$

$$u = y/G$$

# BLOK DİYAGRAMLARIN SADELEŞTİRİLME KURALLARI

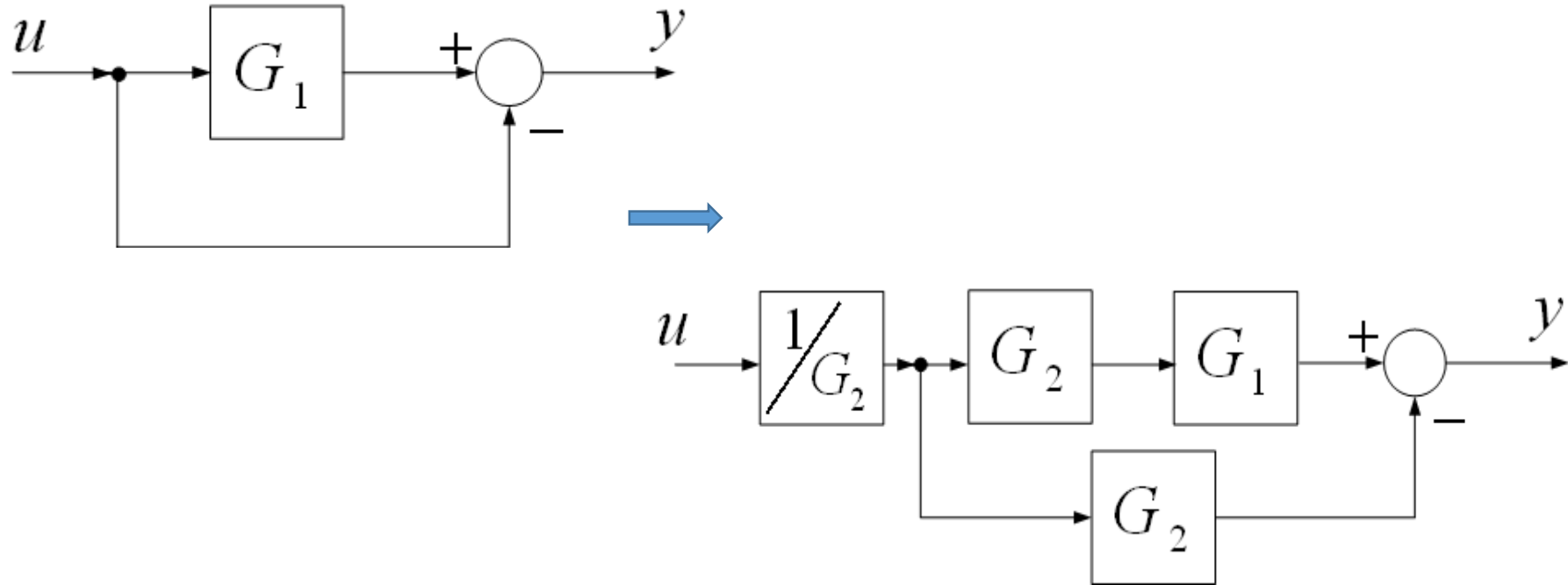
Bloğun ileri besleme yolundan kaldırılması:



$$y = (G_1 - G_2)u$$

# BLOK DİYAGRAMLARIN SADELEŞTİRİLME KURALLARI

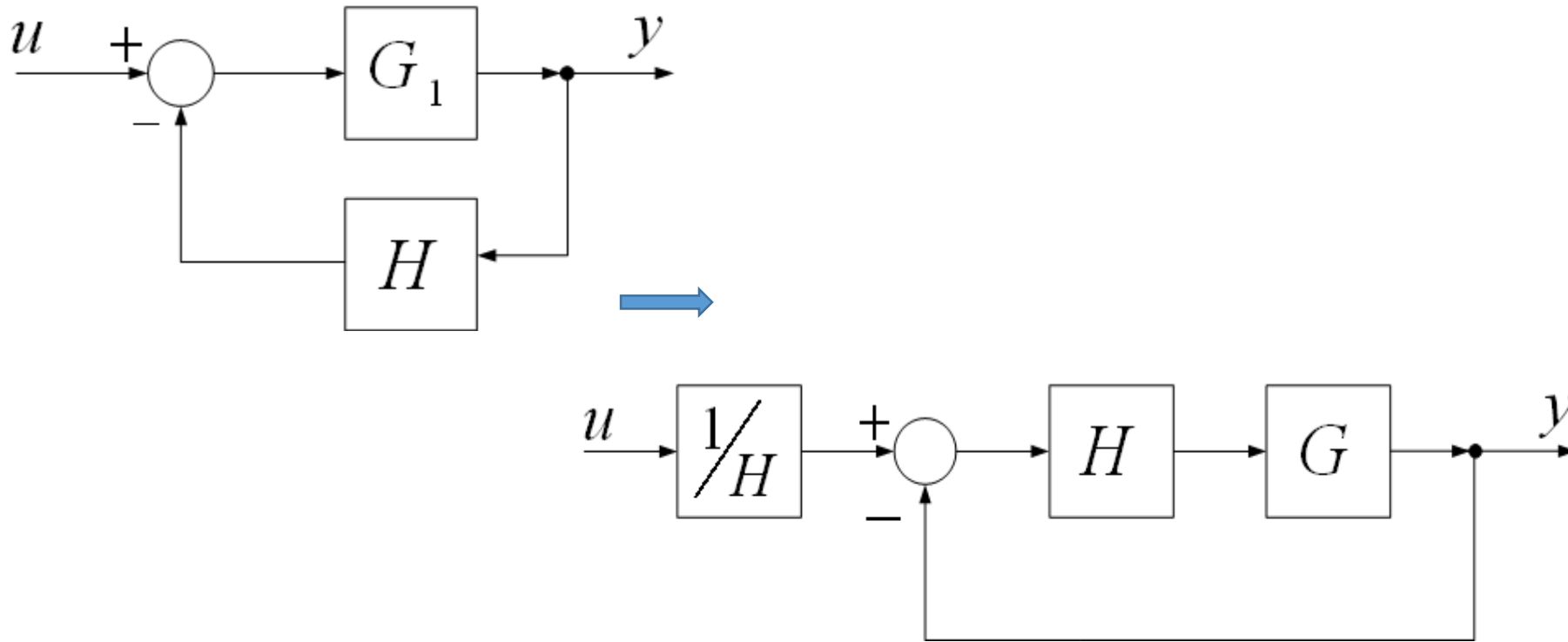
İleri besleme yoluna blok eklenmesi:



$$y = G_1 u - u$$

# BLOK DİYAGRAMLARIN SADELEŞTİRİLME KURALLARI

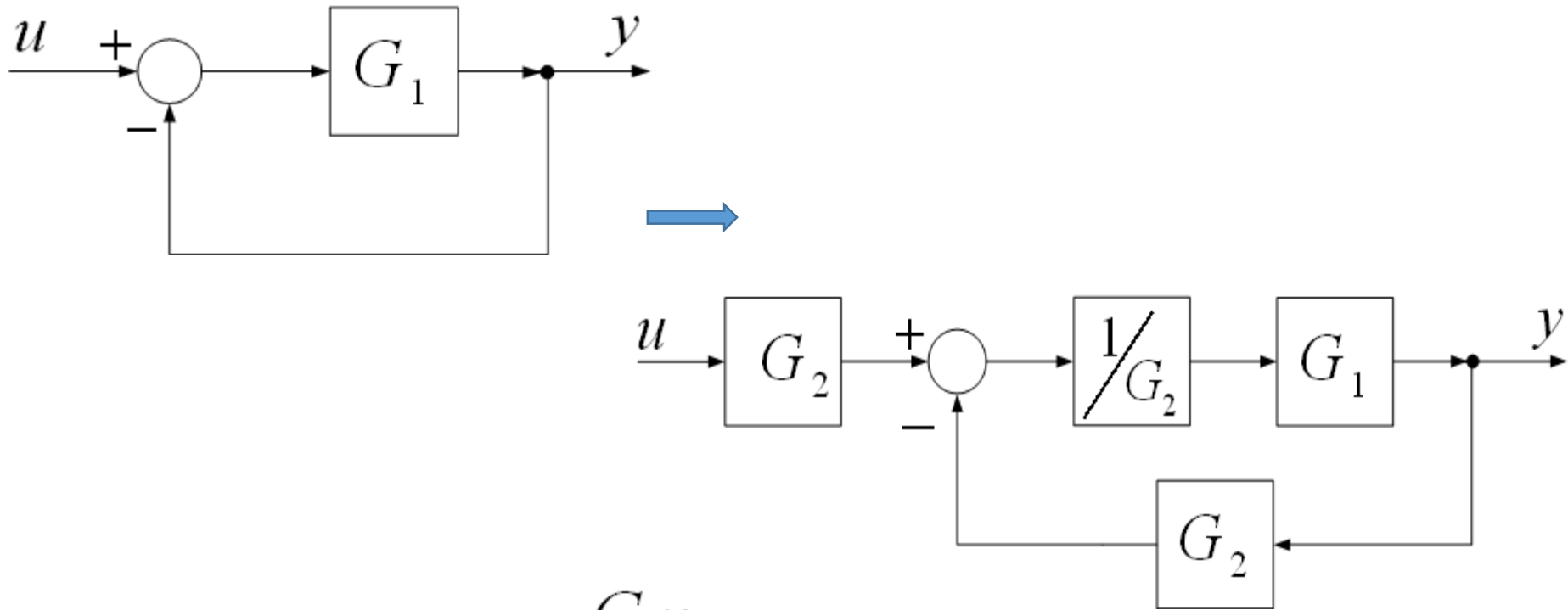
Bloğun geri besleme yolundan kaldırılması:



$$y = \frac{Gu}{1 + GH}$$

# BLOK DİYAGRAMLARIN SADELEŞTİRİLME KURALLARI

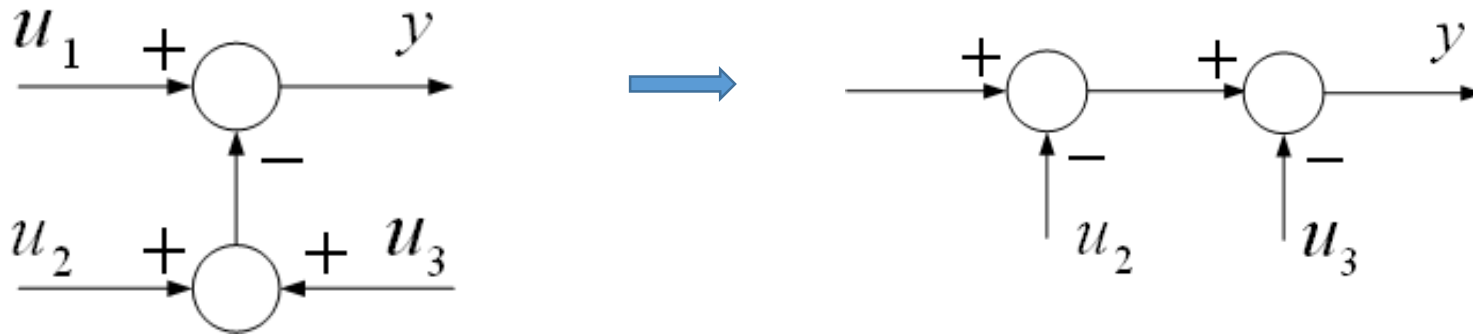
Geri besleme yoluna blok eklenmesi:



$$y = \frac{G_1 u}{1 + G_1}$$

# BLOK DİYAGRAMLARIN SADELEŞTİRİLME KURALLARI

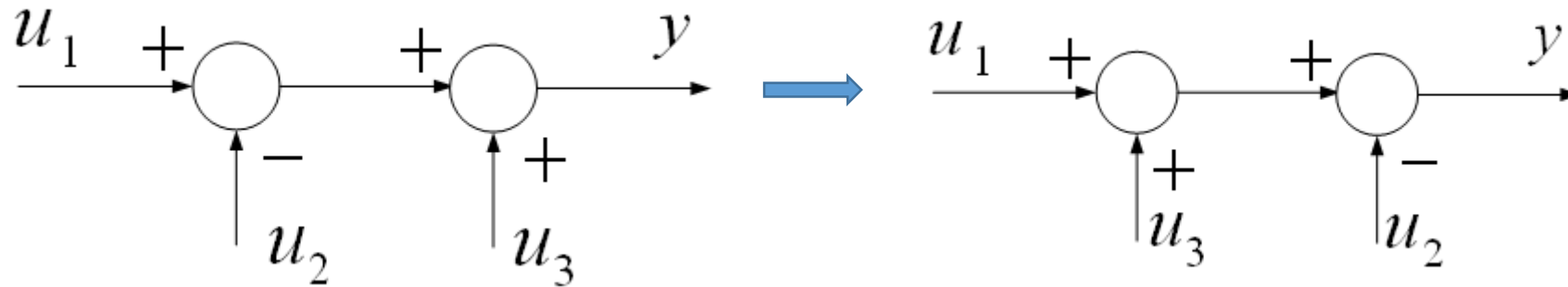
Toplama noktalarının düzenlenmesi:



$$y = u_1 - u_2 - u_3$$

# BLOK DİYAGRAMLARIN SADELEŞTİRİLME KURALLARI

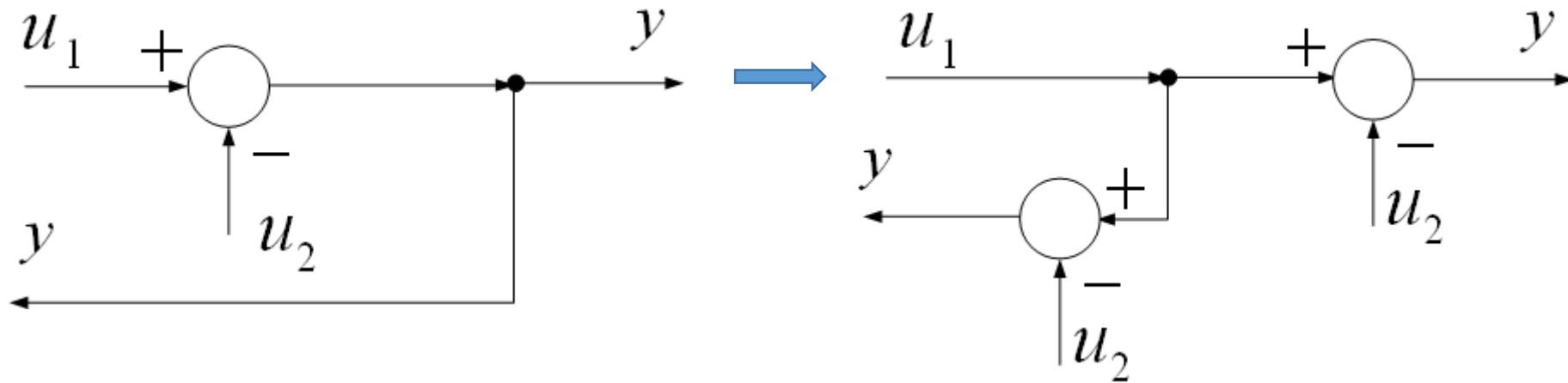
Toplama noktalarının birbiriyle yer değiştirmesi:



$$y = u_1 - u_2 + u_3$$

# BLOK DİYAGRAMLARIN SADELEŞTİRİLME KURALLARI

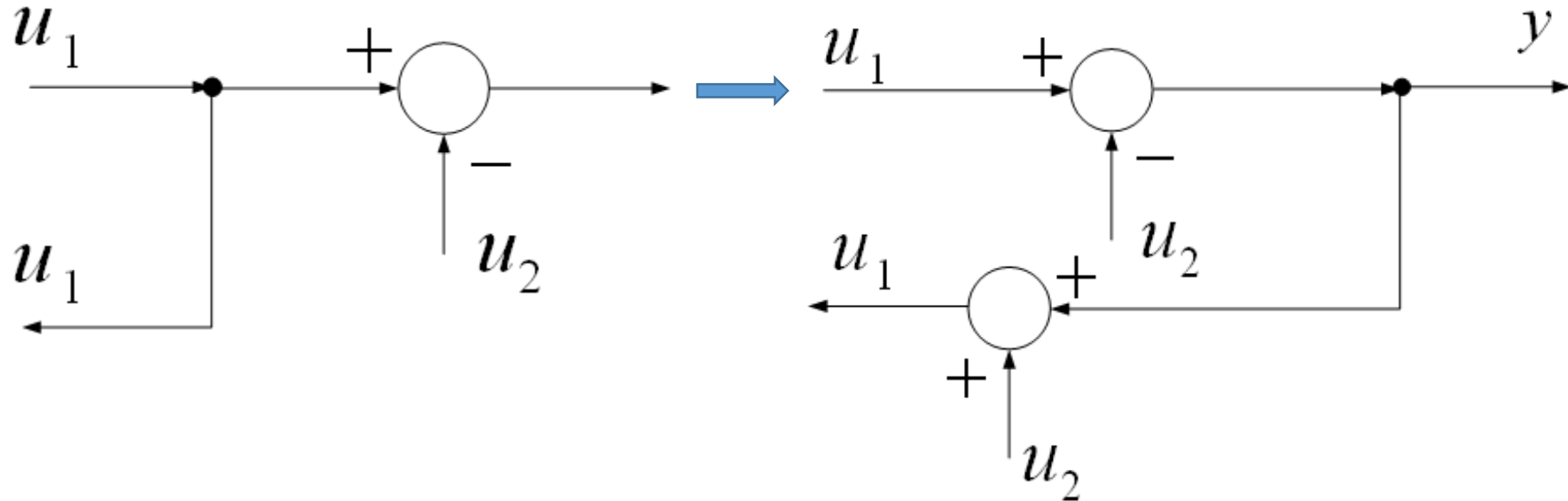
Ayrılma noktasının toplama noktasının önüne (girişe doğru) kaydırılması:



$$y = u_1 - u_2$$

# BLOK DİYAGRAMLARIN SADELEŞTİRİLME KURALLARI

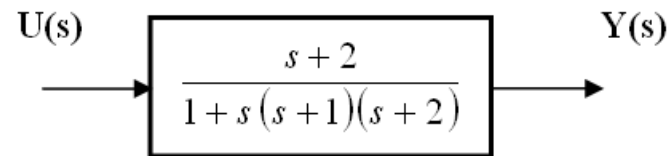
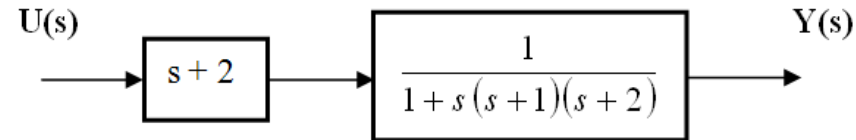
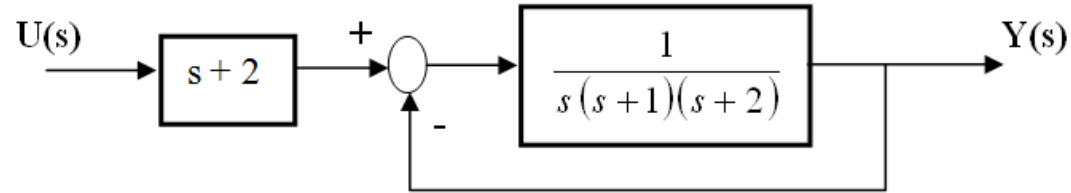
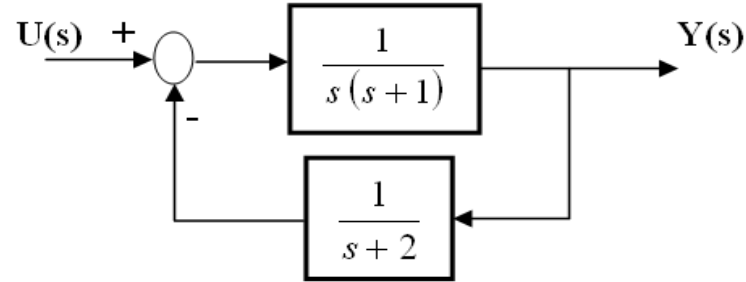
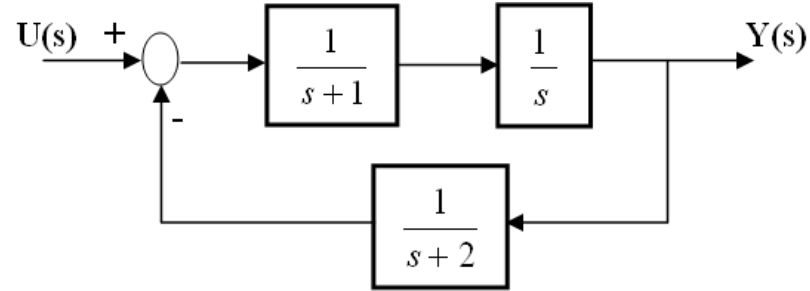
Ayrılma noktasının toplama noktasının arkasına (çıkışa doğru) kaydırılması:



$$y = u_1 - u_2$$
$$u_1 = y + u_2$$

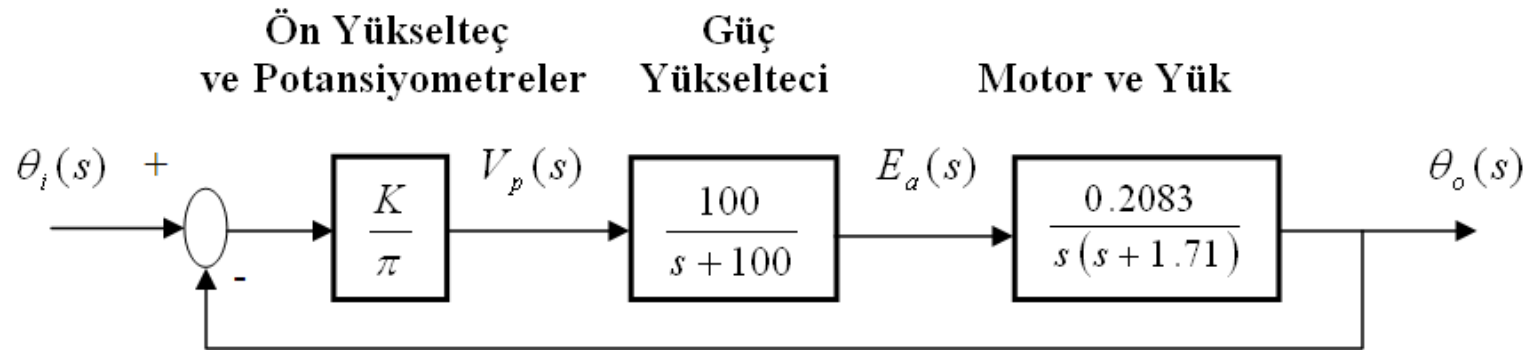
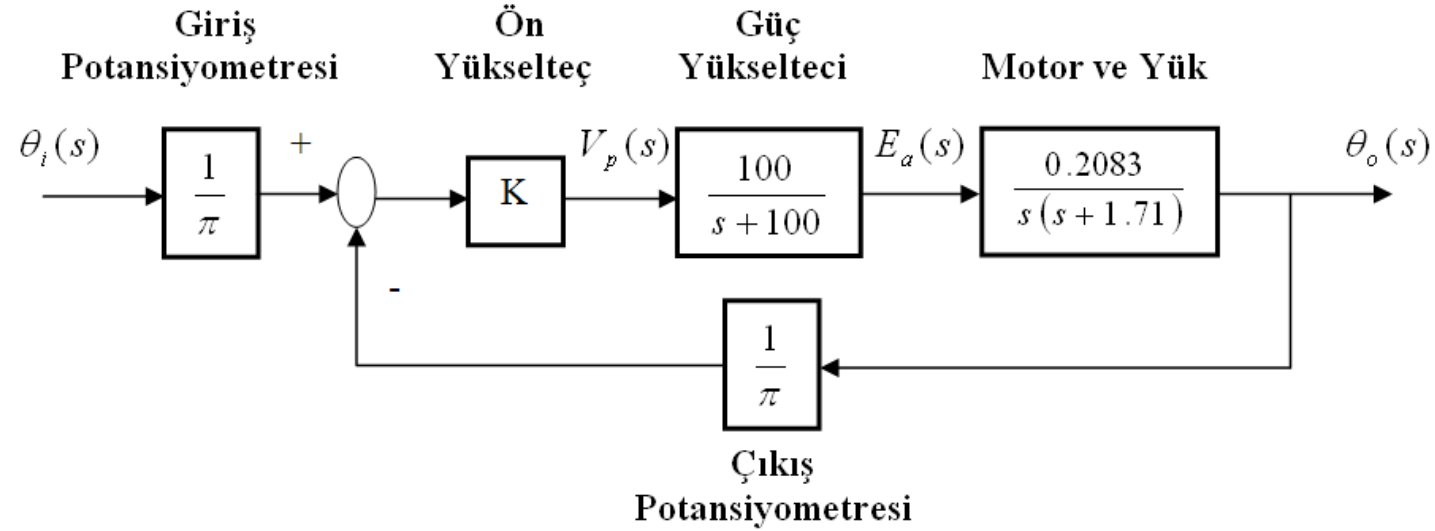
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

## Örnek 1:



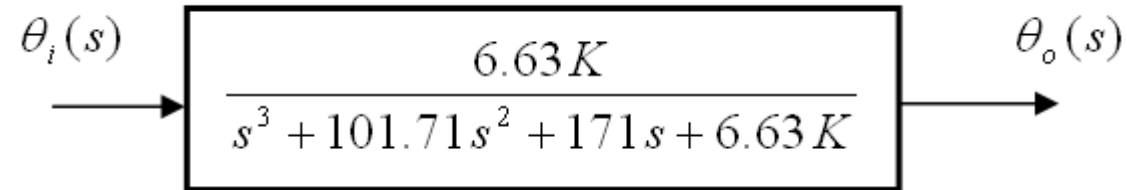
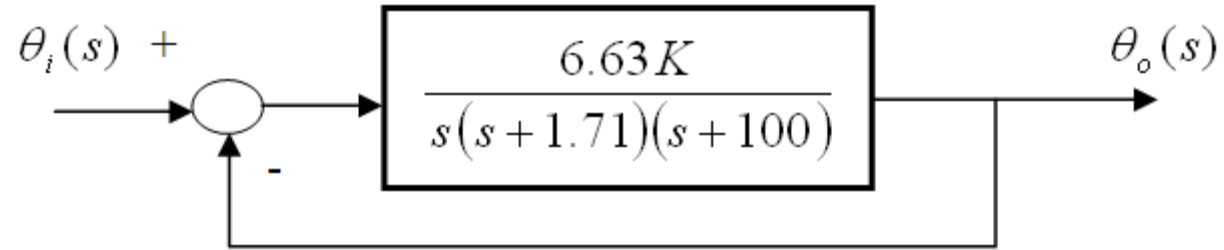
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

## Örnek 2:



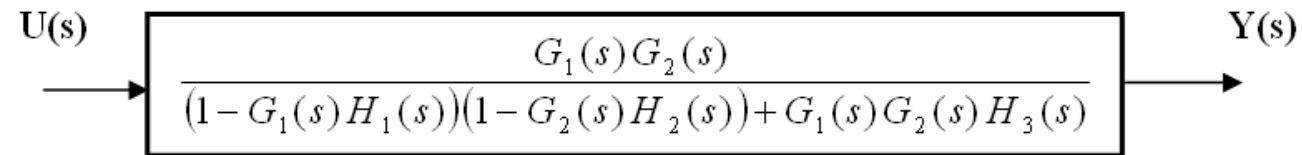
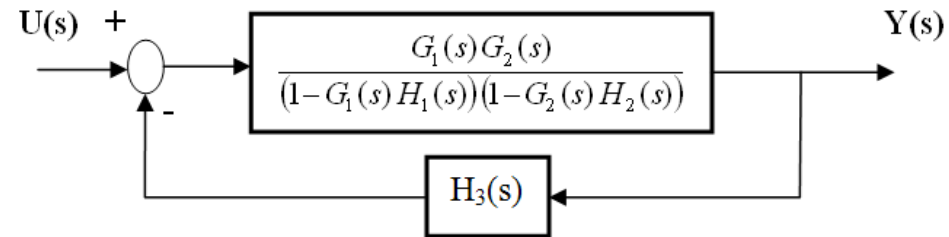
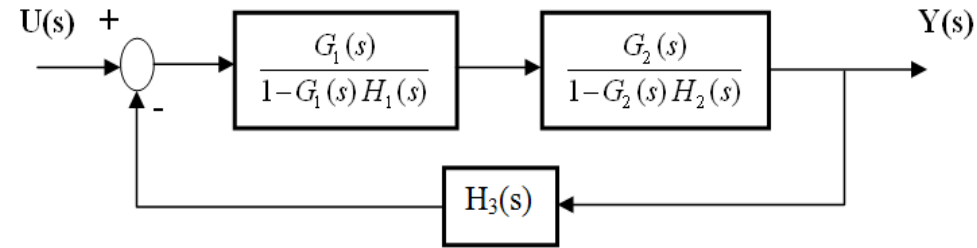
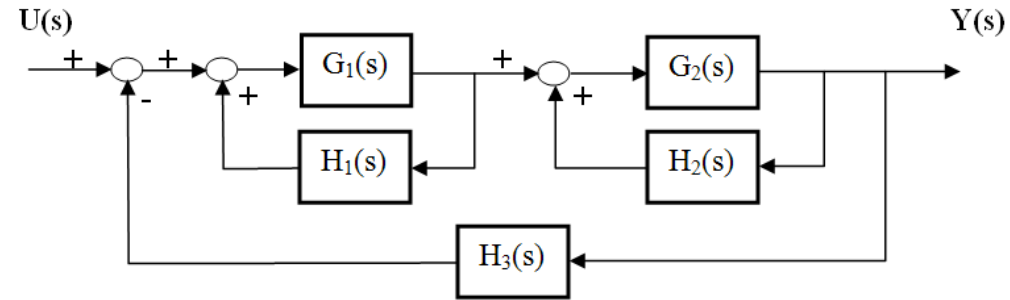
## BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Örnek 2 devam:



# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

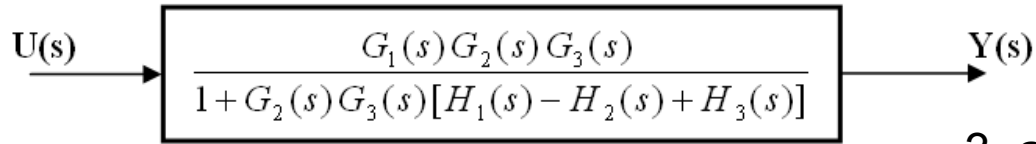
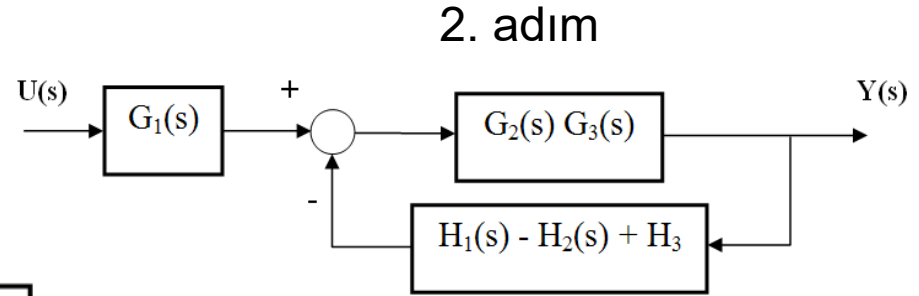
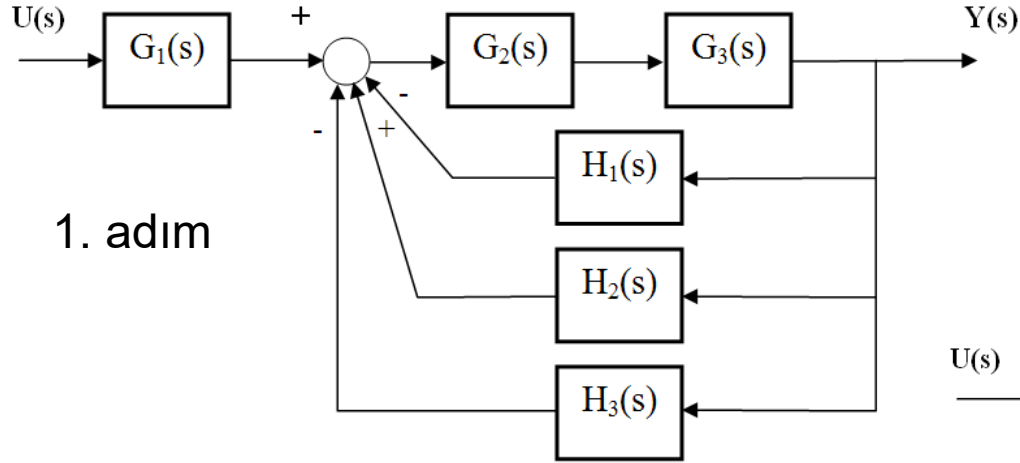
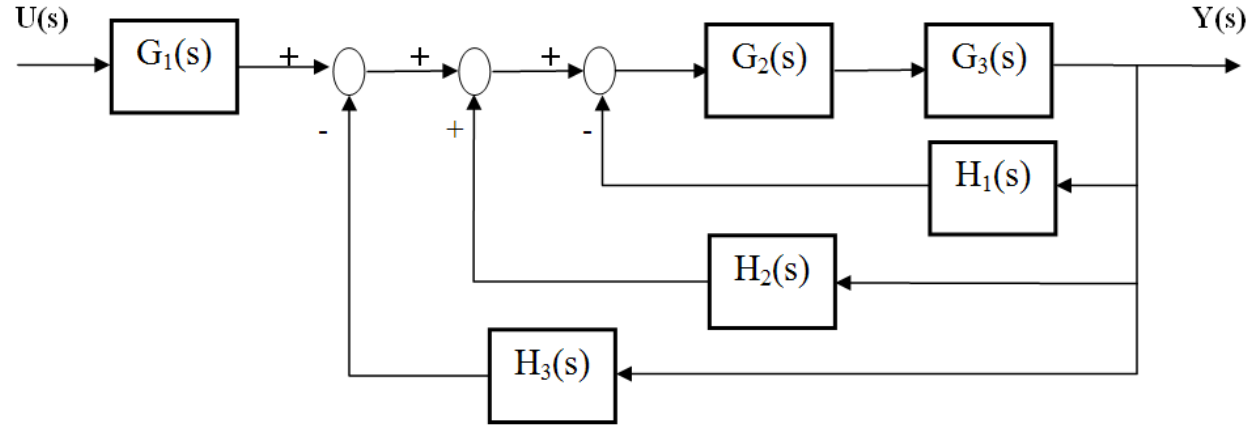
## Örnek 3:





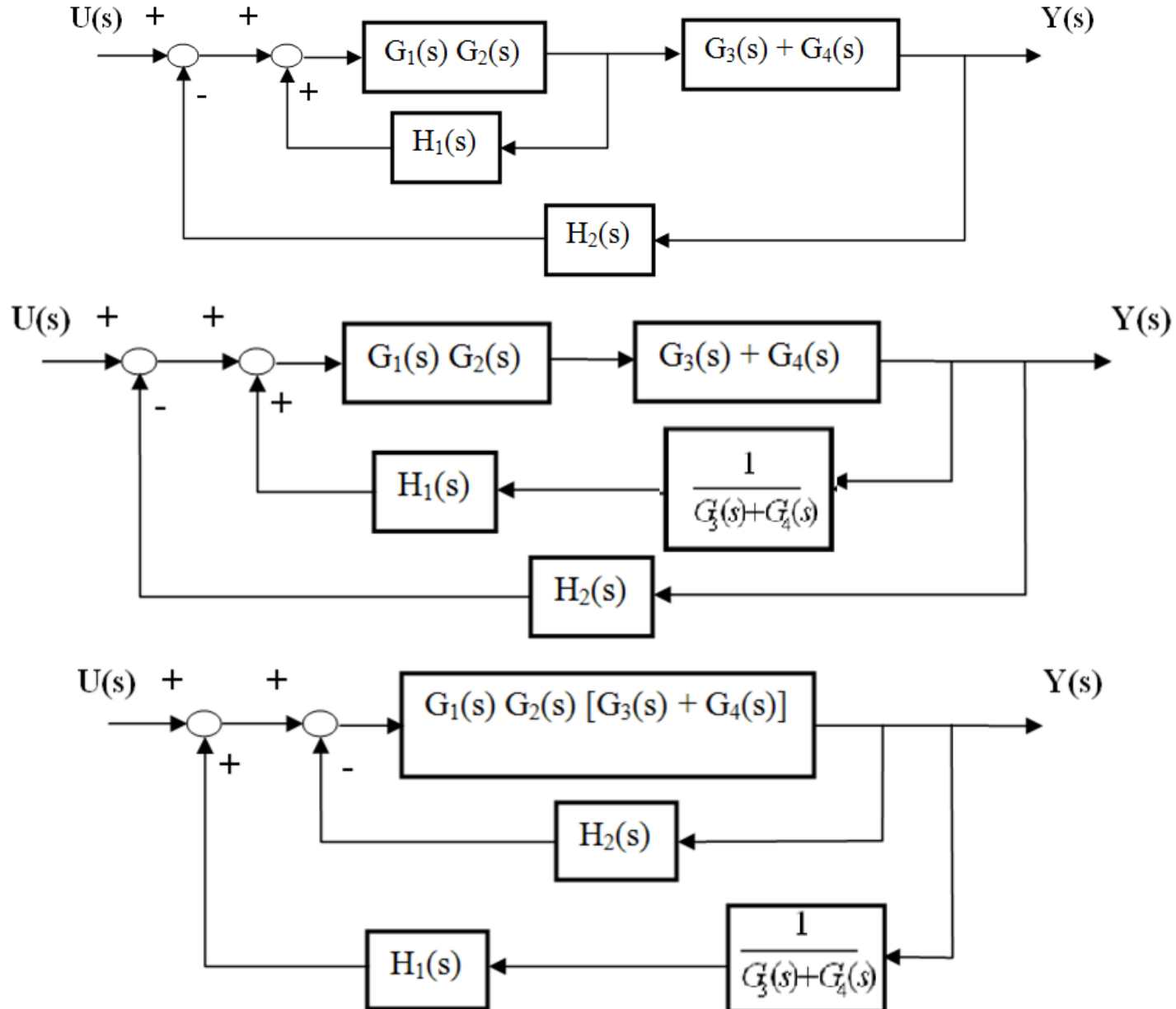
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Örnek 4:



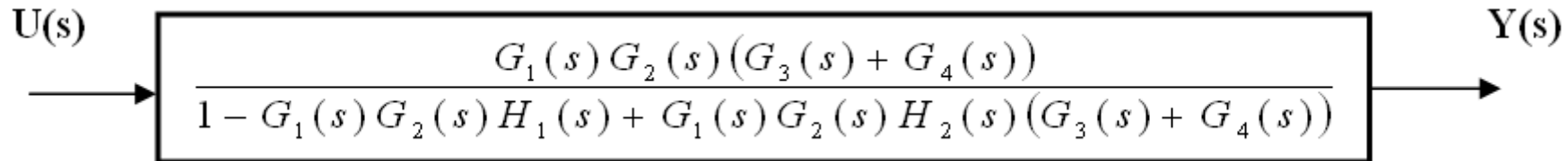
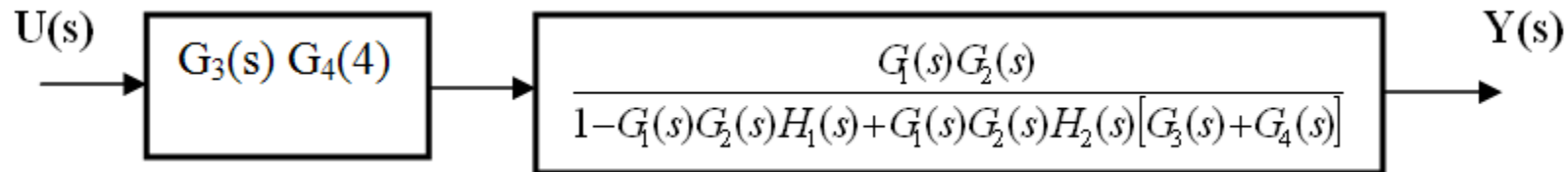
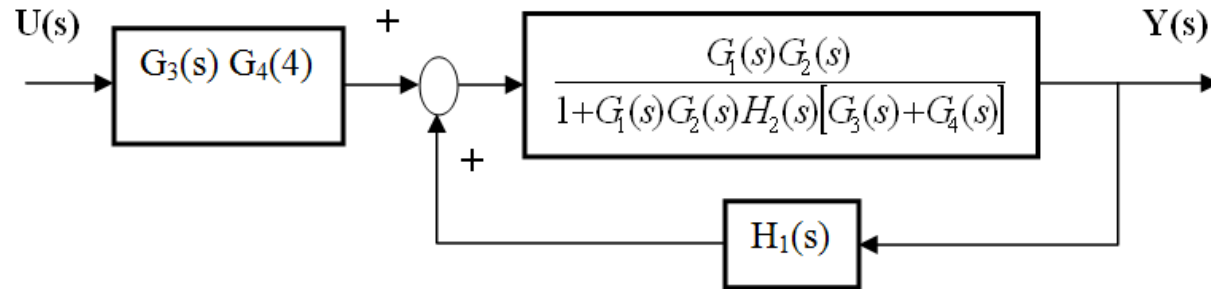
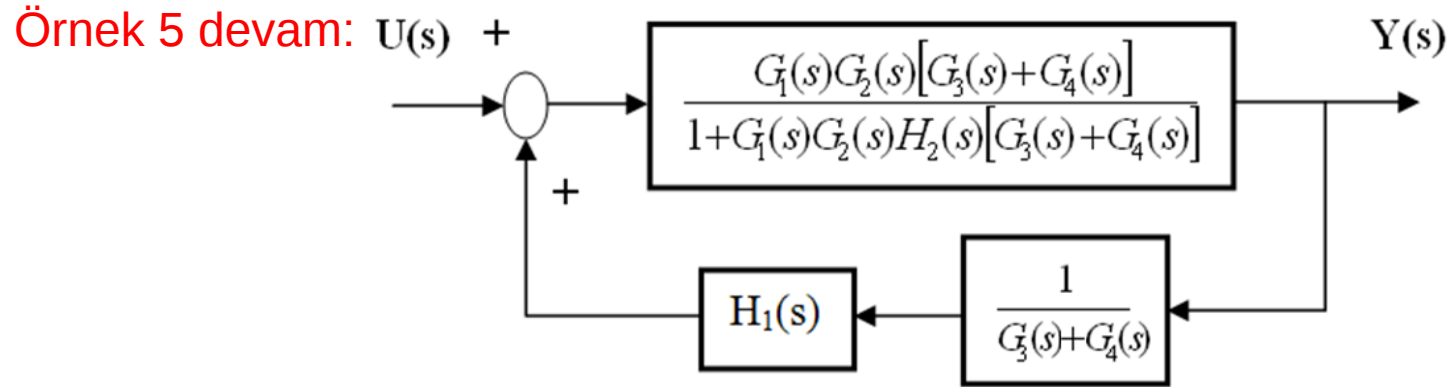
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Örnek 5:



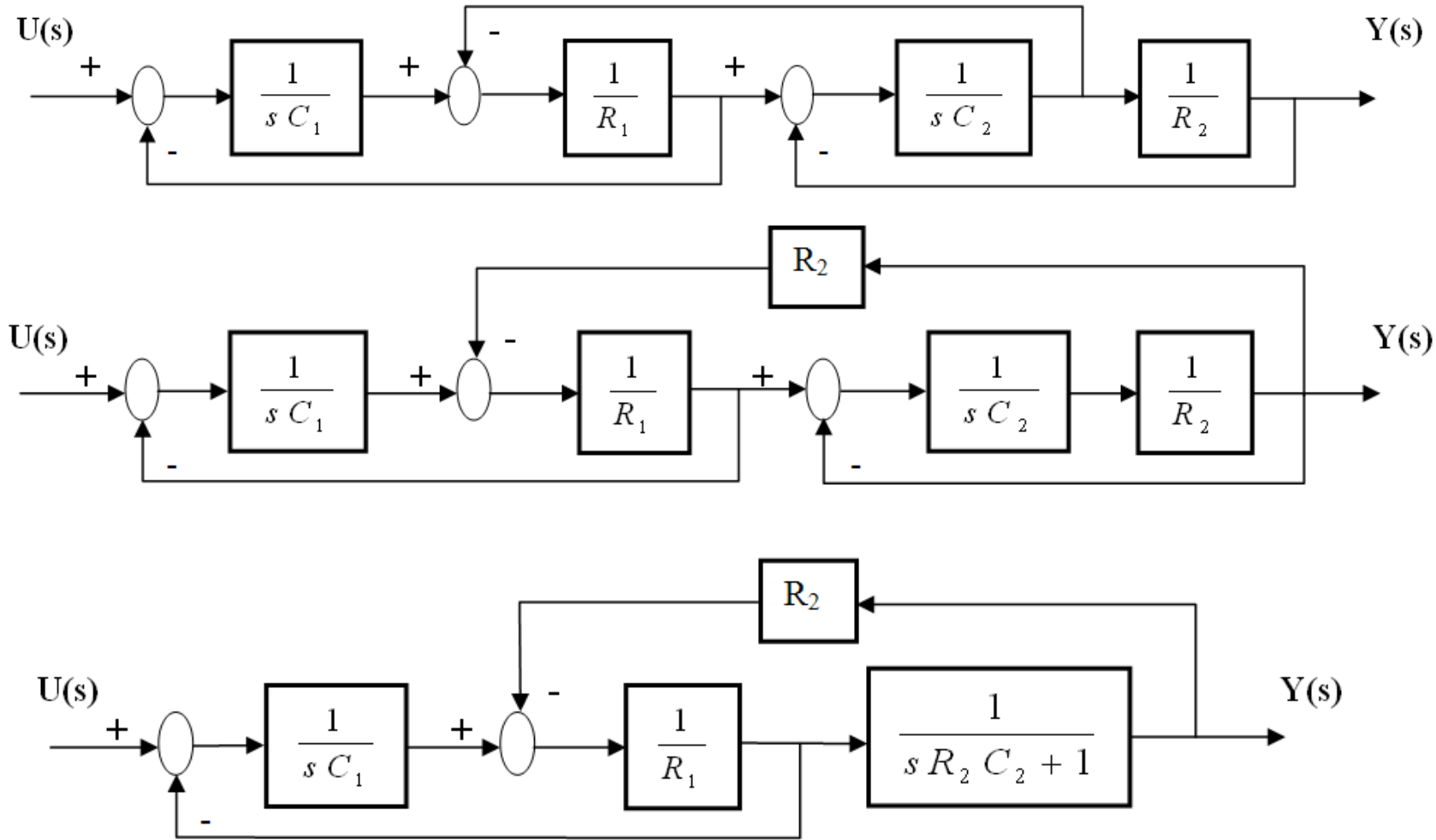
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Örnek 5 devam:



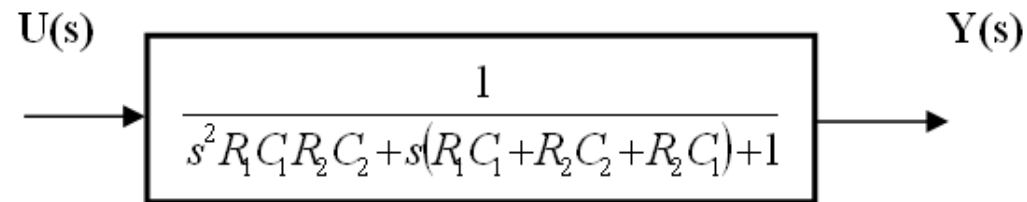
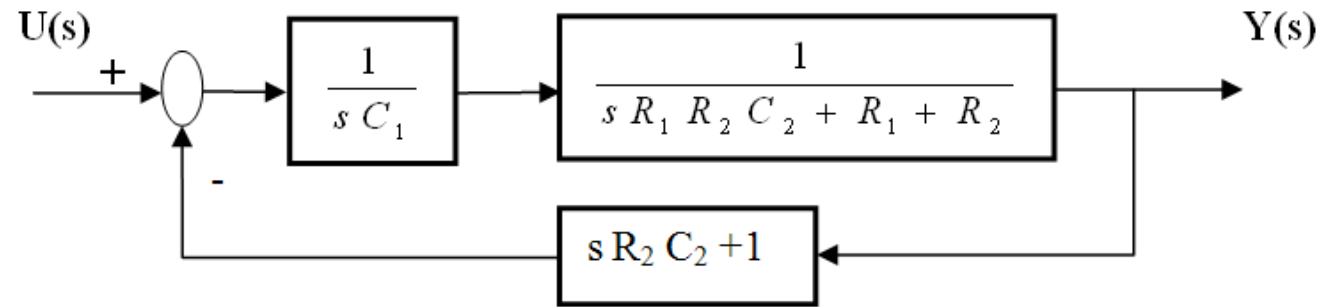
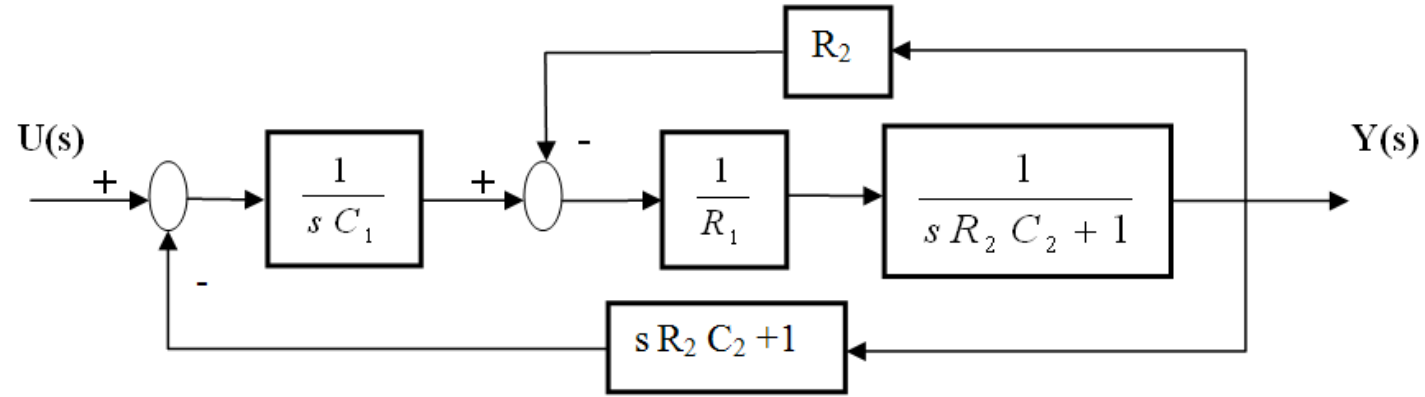
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

## Örnek 6:



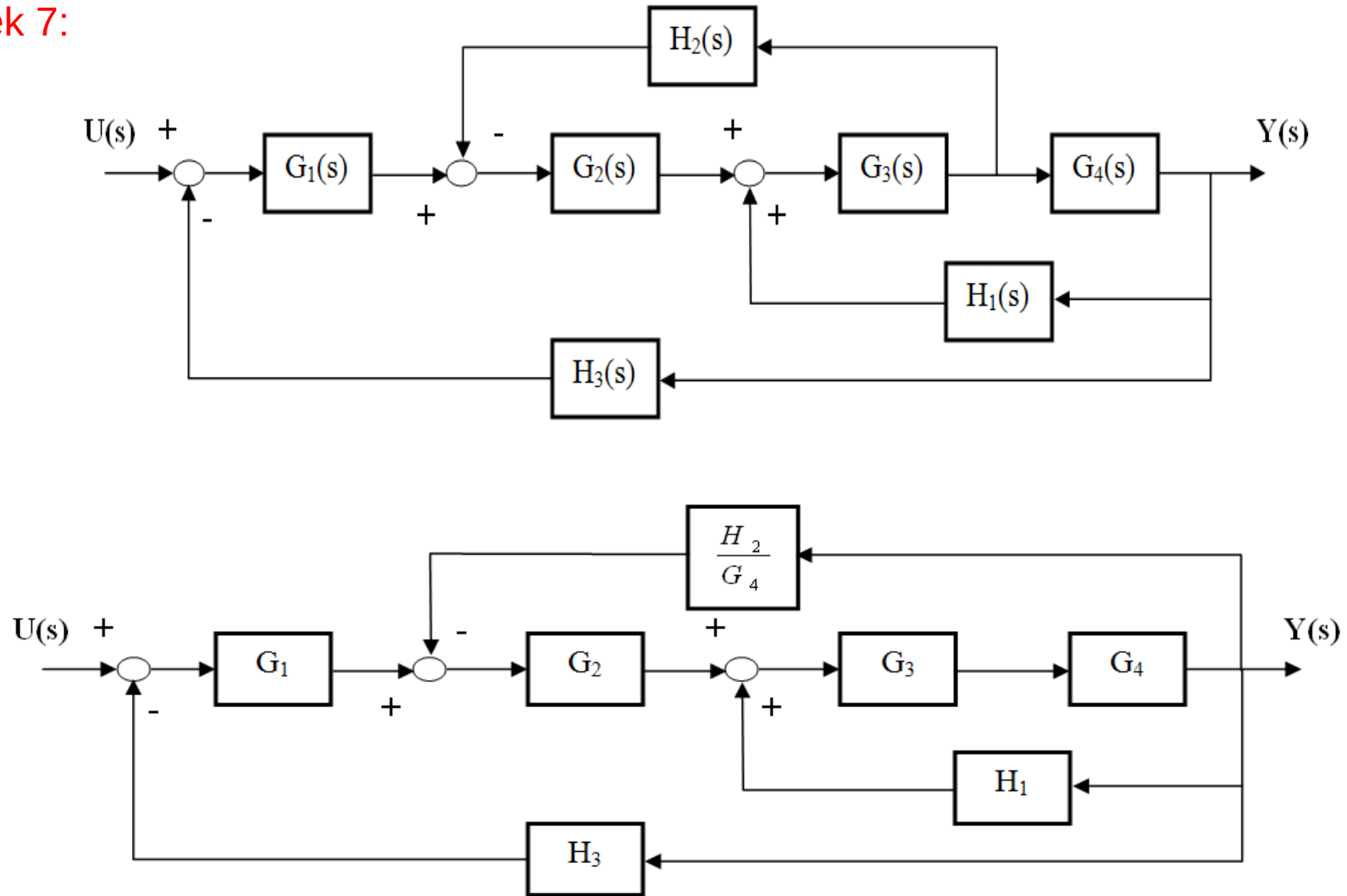
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Örnek 6 devam:



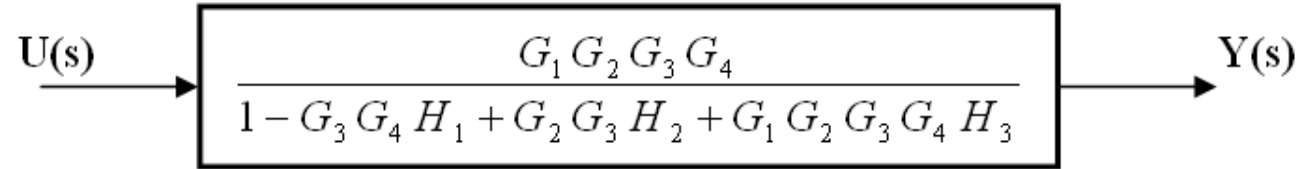
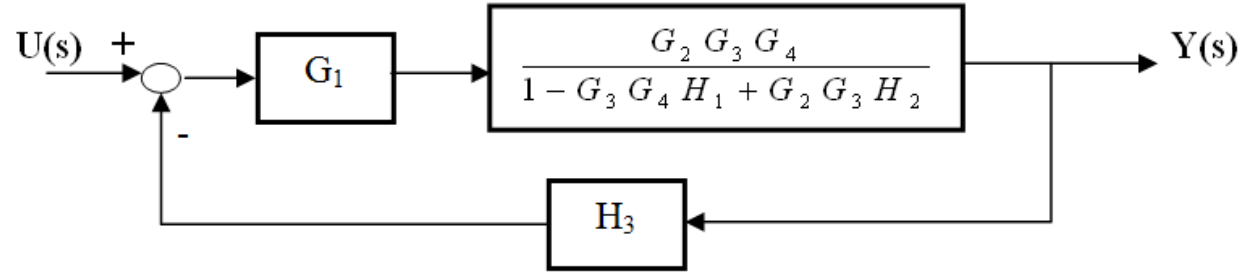
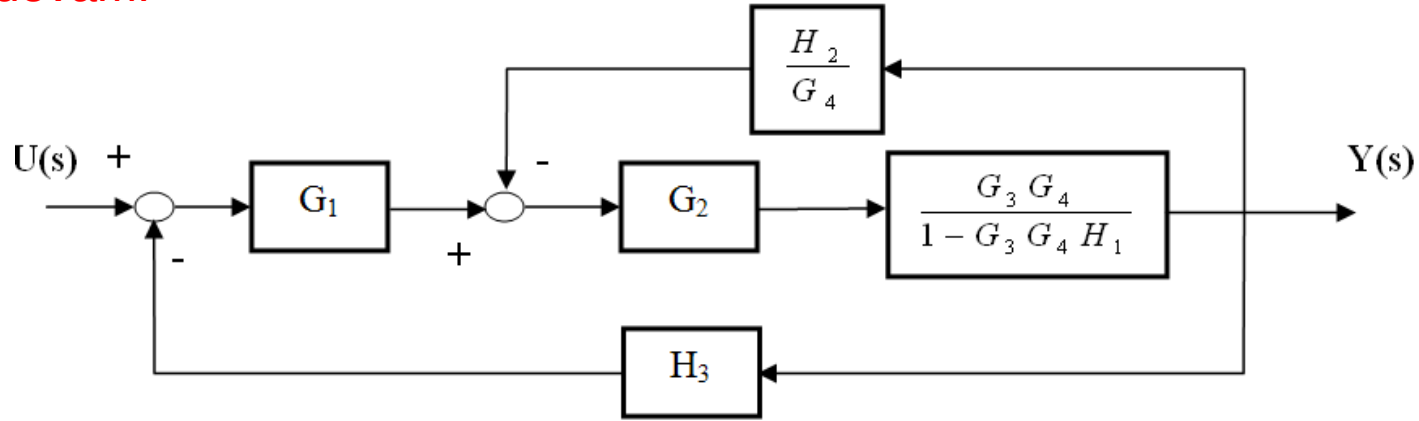
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

## Örnek 7:



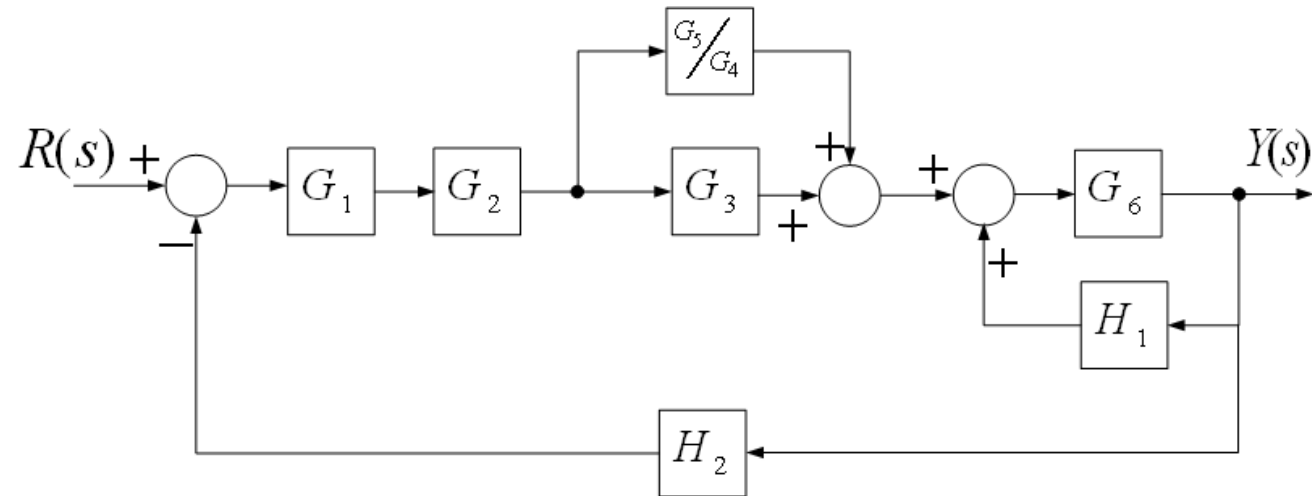
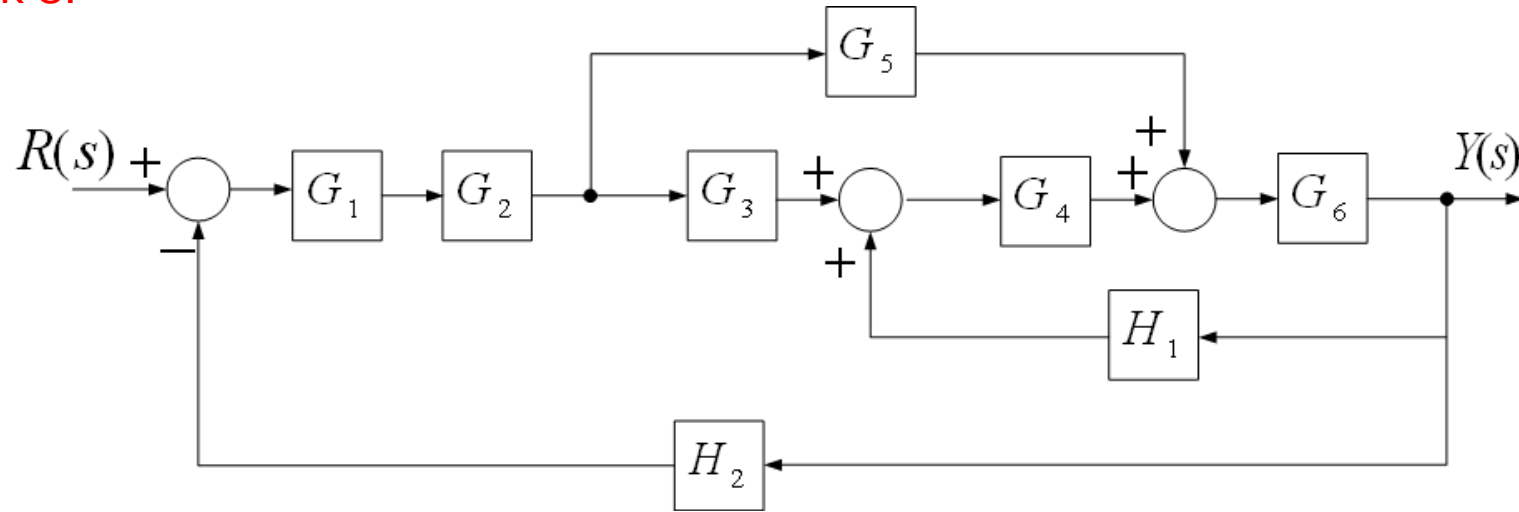
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Örnek 7 devam:



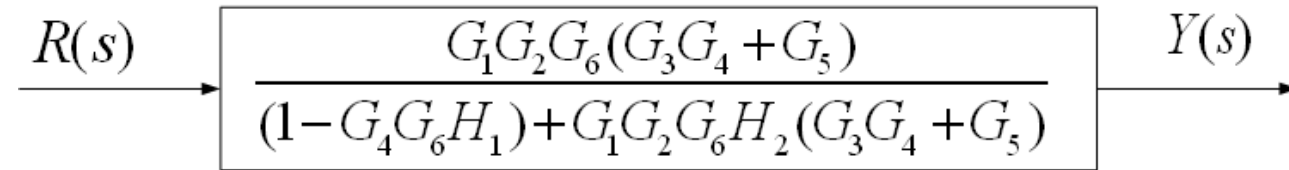
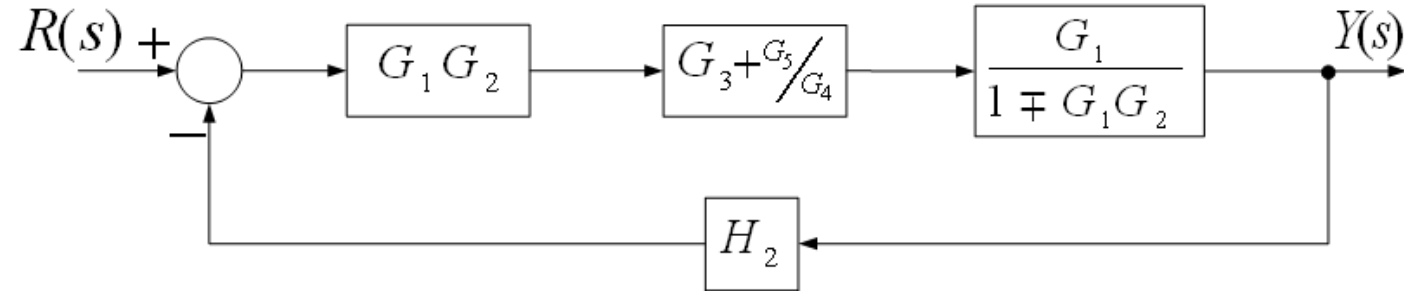
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

## Örnek 8:



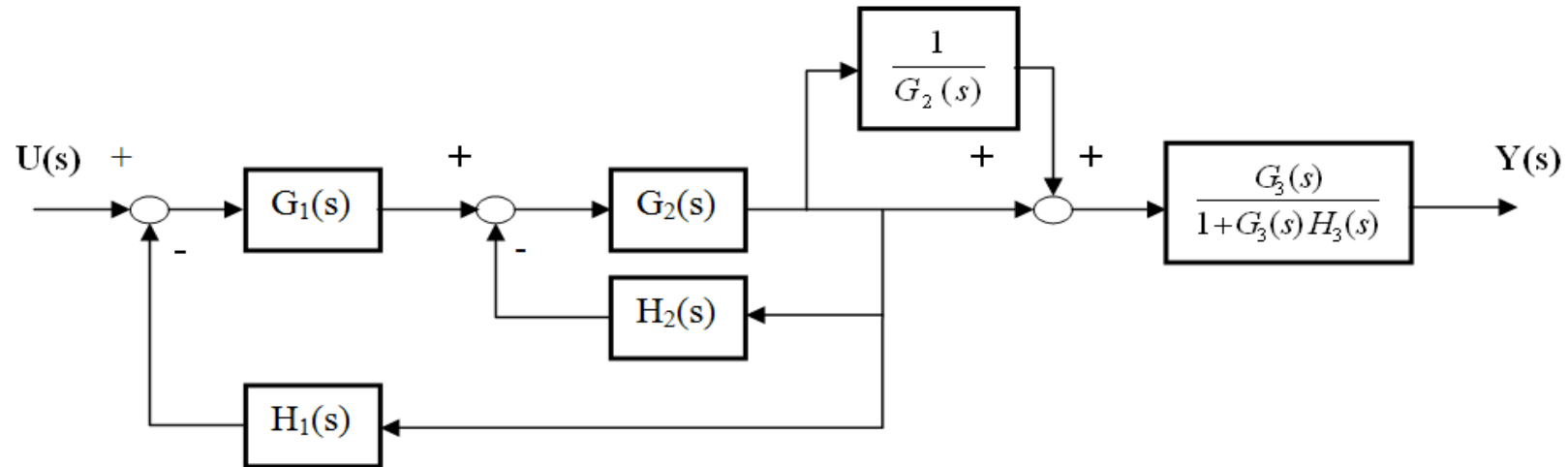
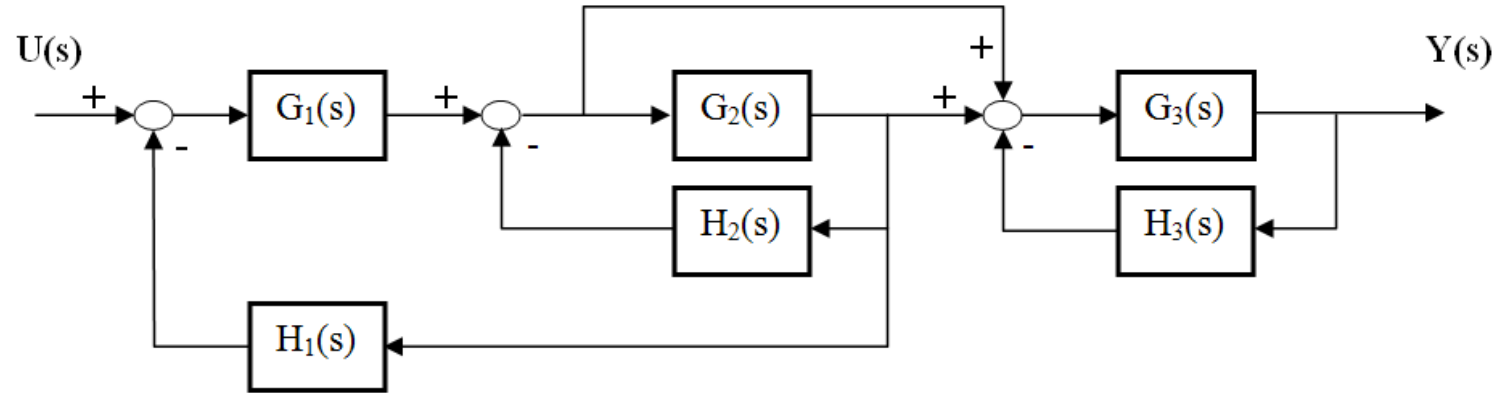
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Örnek 8 devam:



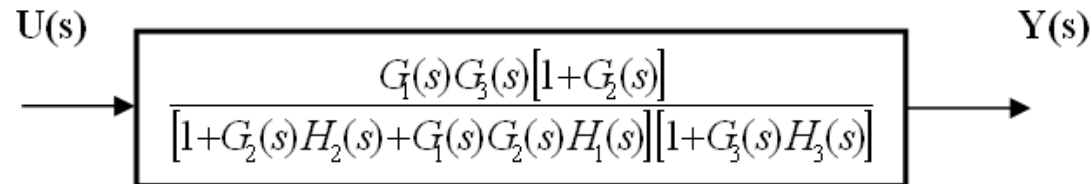
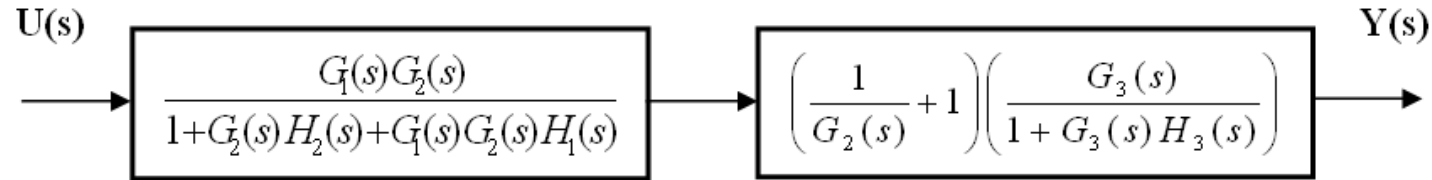
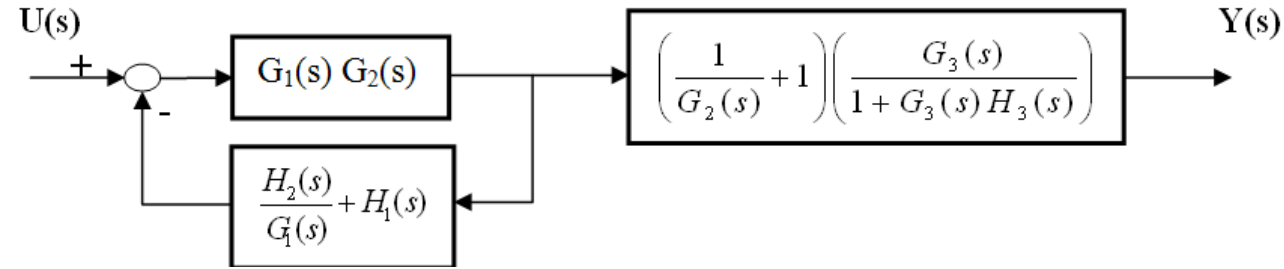
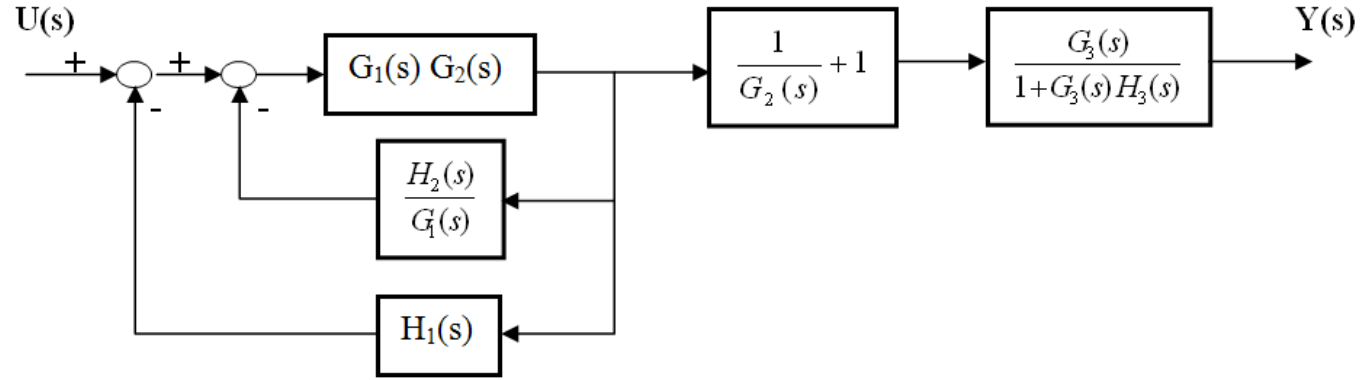
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

## Örnek 9:



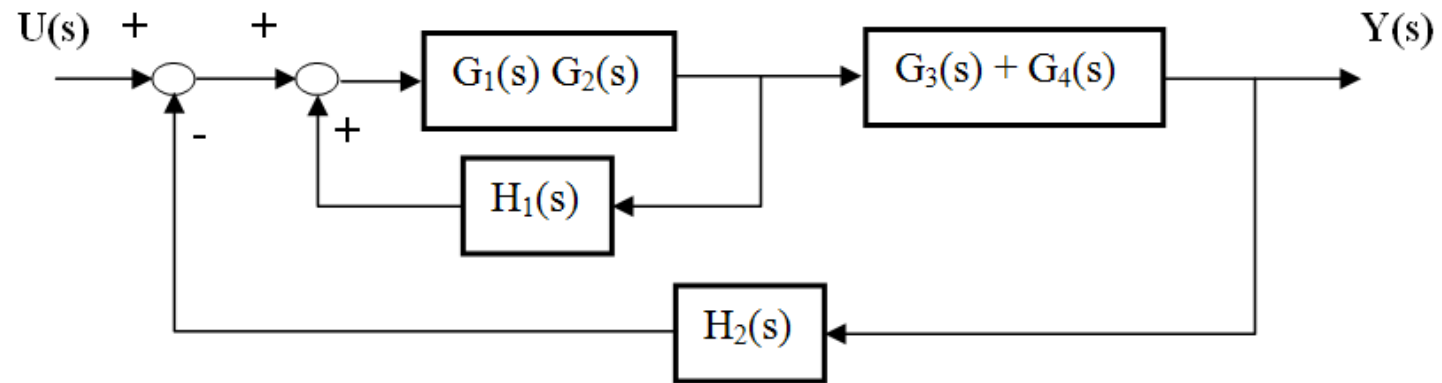
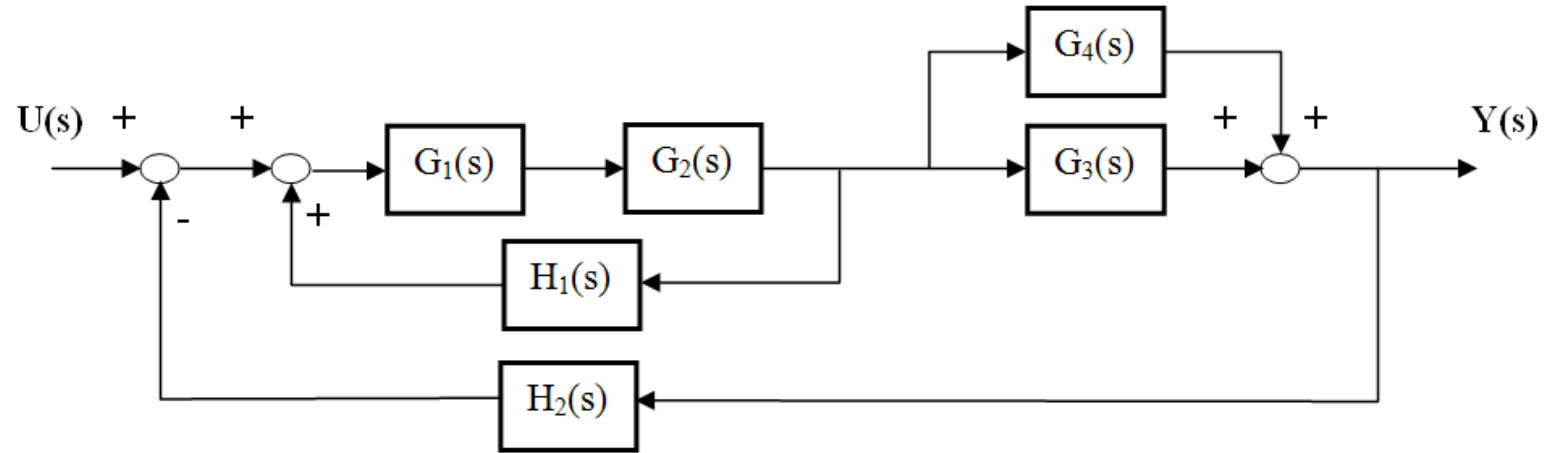
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Örnek 9 devam:



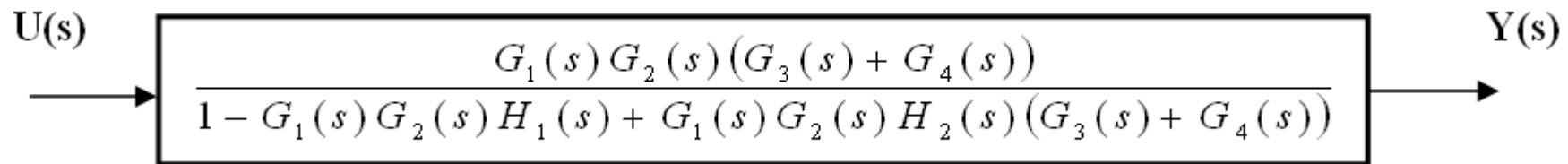
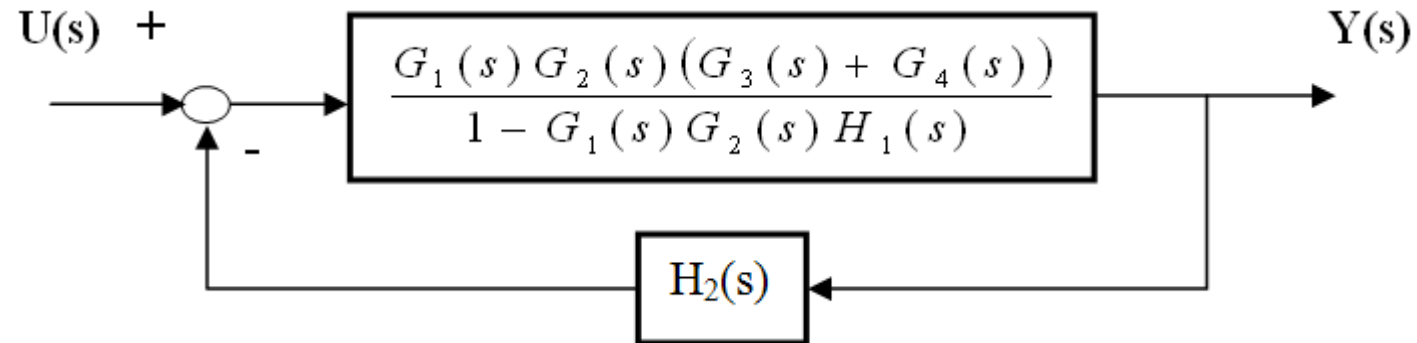
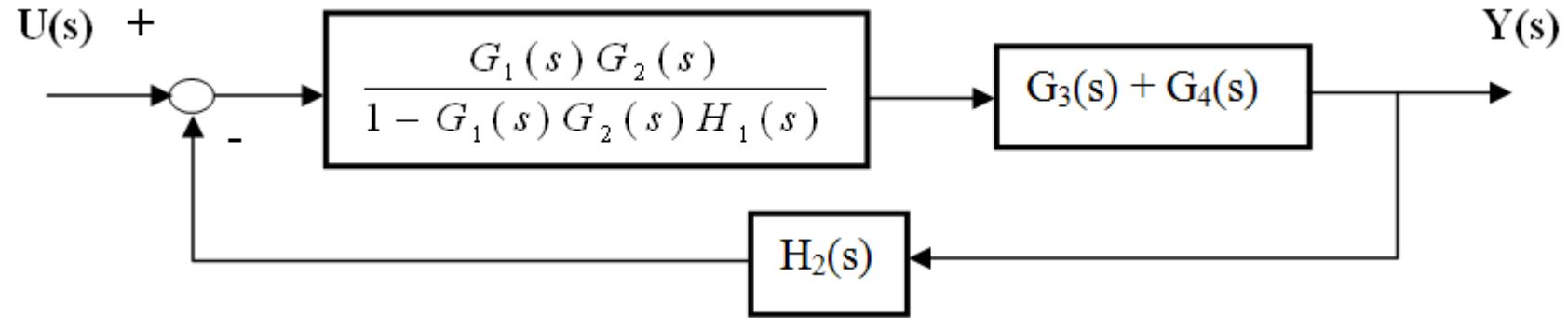
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

## Örnek 10:



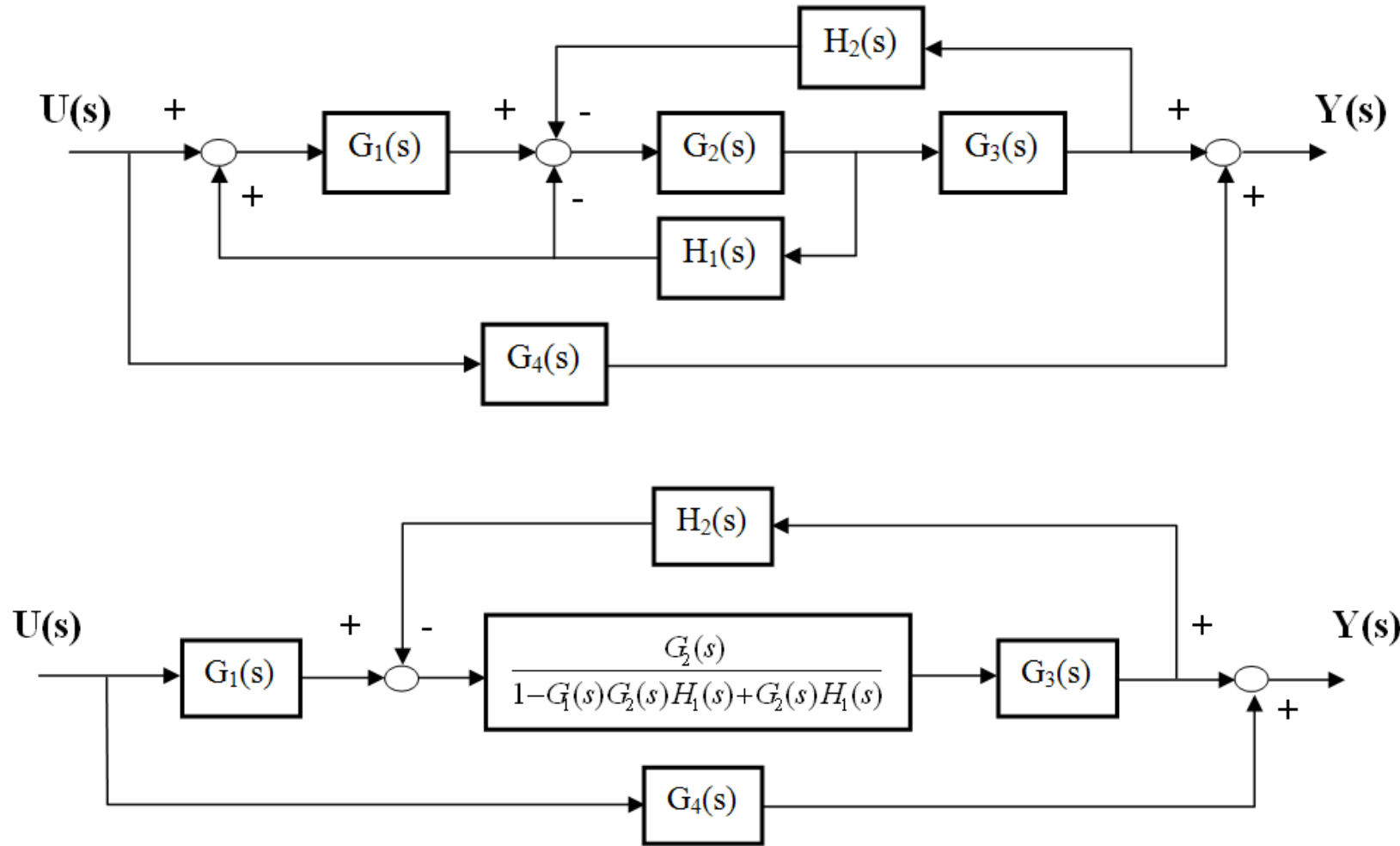
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Örnek 10 devam:



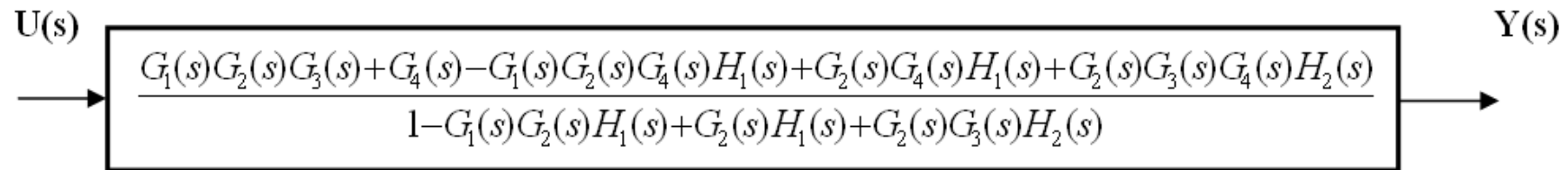
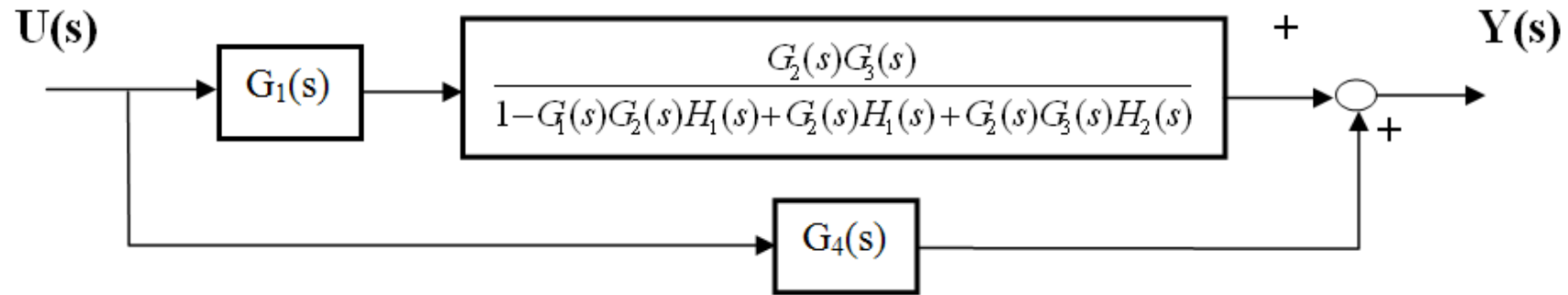
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

## Örnek 11:



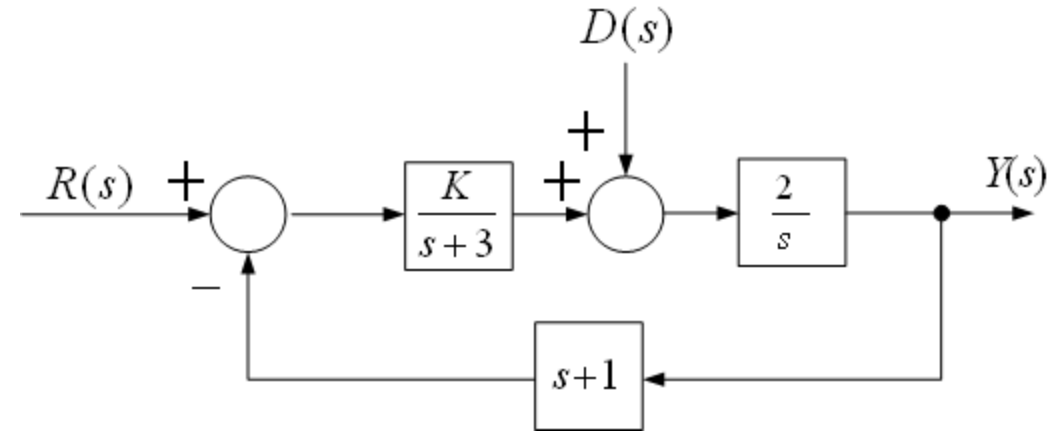
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Örnek 11 devam:



## BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Örnek 12:



$$D(s) = 0 \text{ için} \quad \frac{Y(s)}{R(s)} = \frac{2K}{s(s+3) + 2K(s+1)}$$

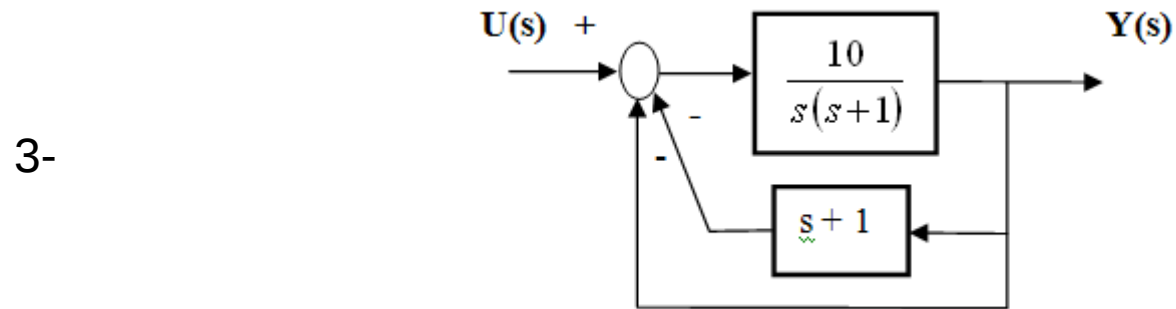
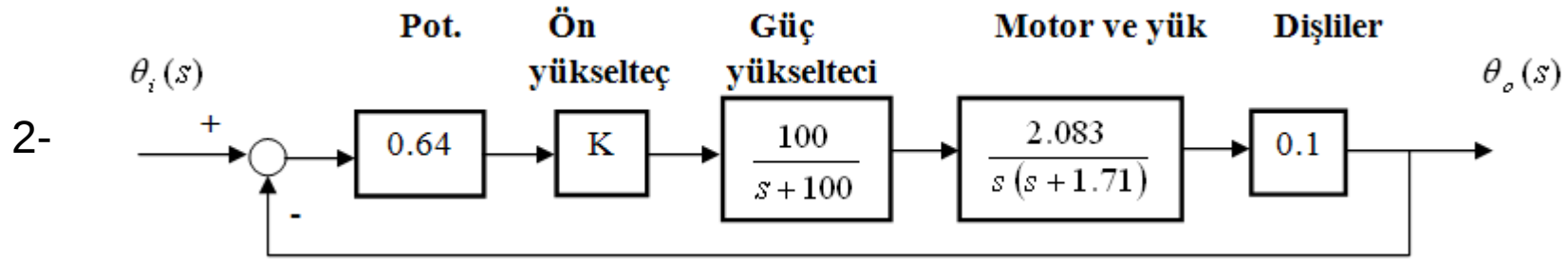
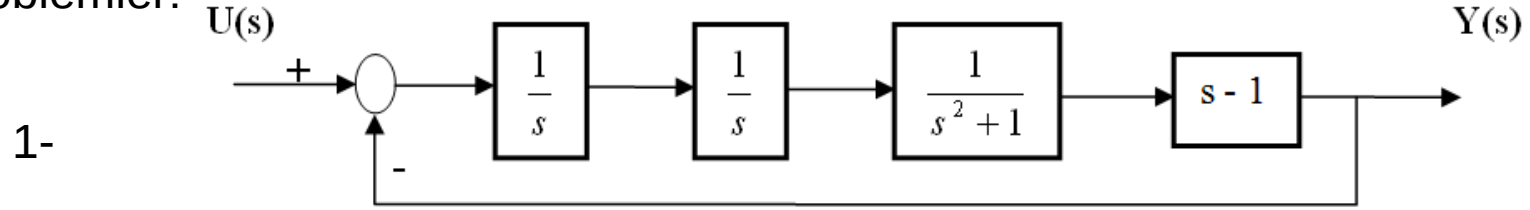
$$R(s) = 0 \text{ için} \quad \frac{Y(s)}{D(s)} = \frac{2(s+3)}{s(s+3) + 2K(s+1)}$$

$$Y(s) = \frac{2K.R(s)}{s(s+3) + 2K(s+1)} + \frac{2(s+3).D(s)}{s(s+3) + 2K(s+1)}$$

$$Y(s) = \frac{2K.R(s) + 2(s+3).D(s)}{s(s+3) + 2K(s+1)}$$

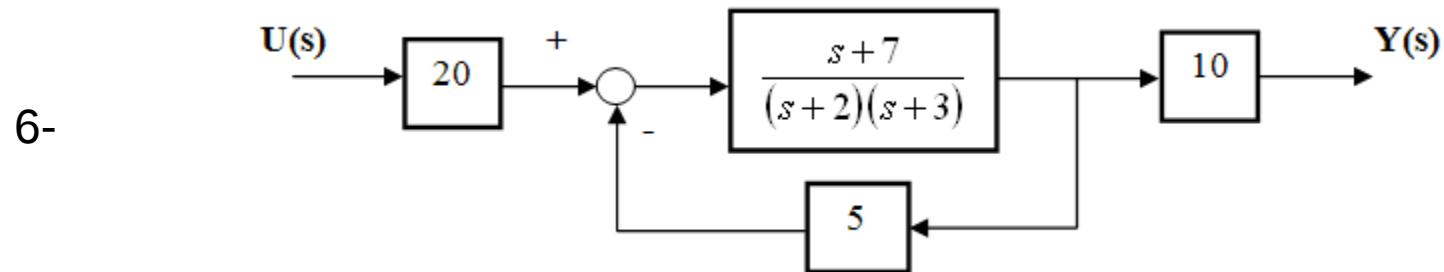
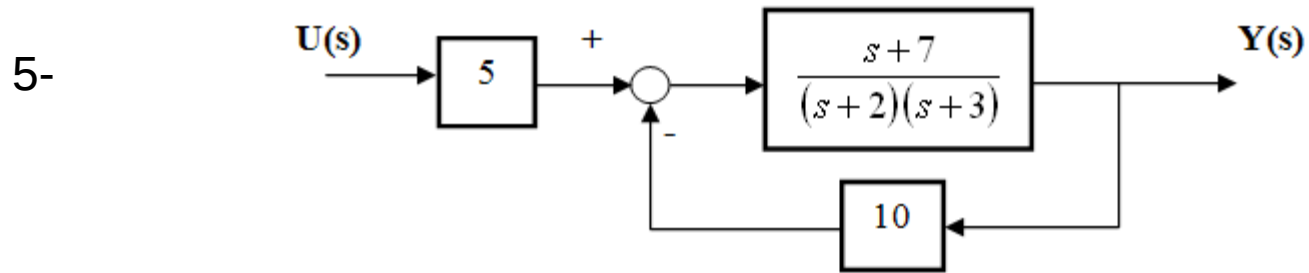
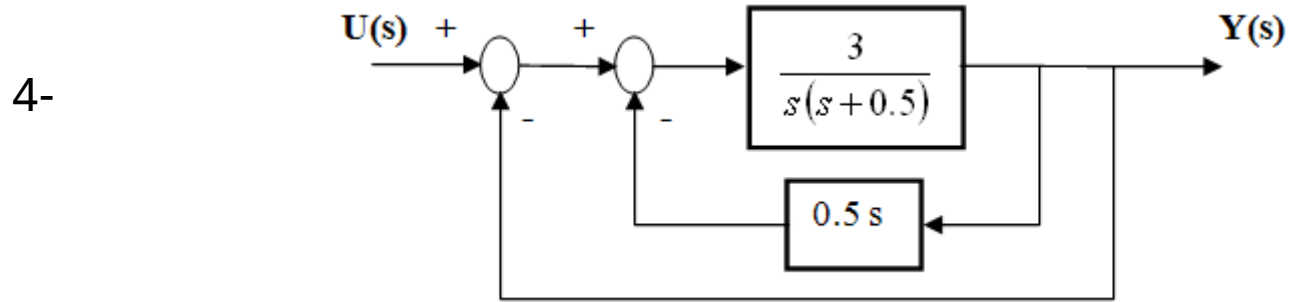
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Problemler:



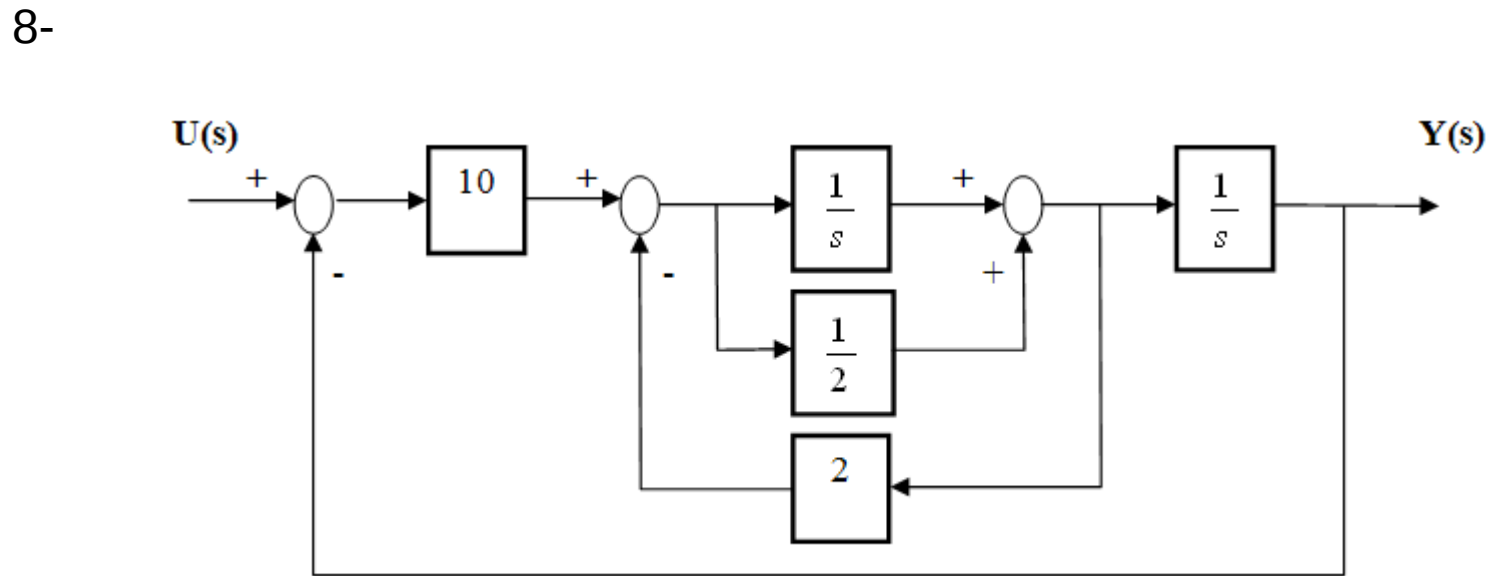
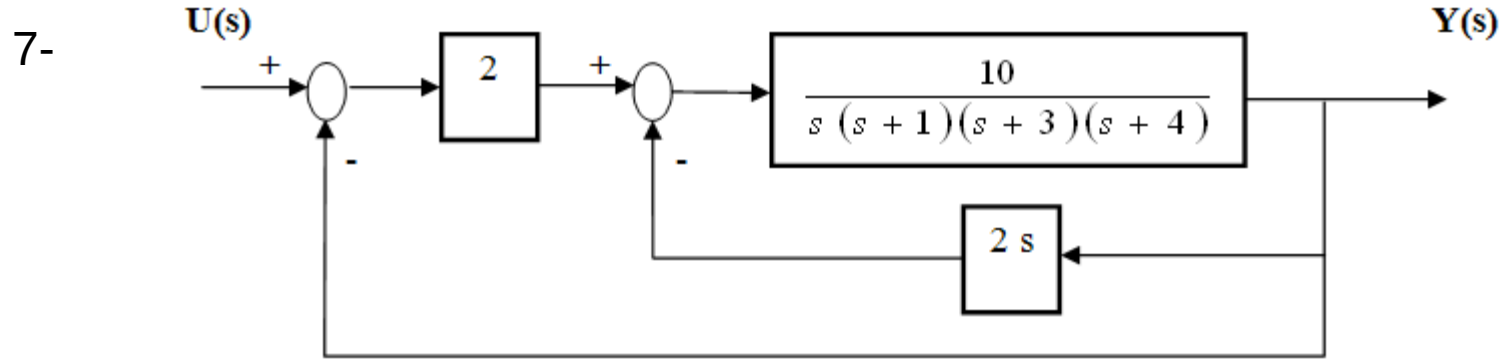
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Problemler:



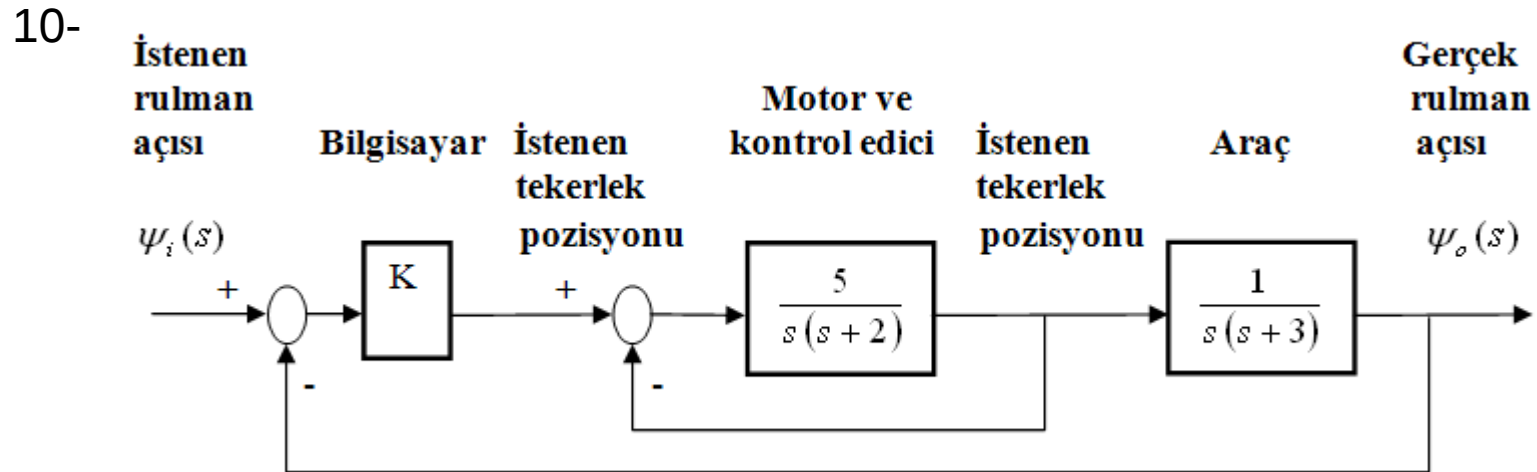
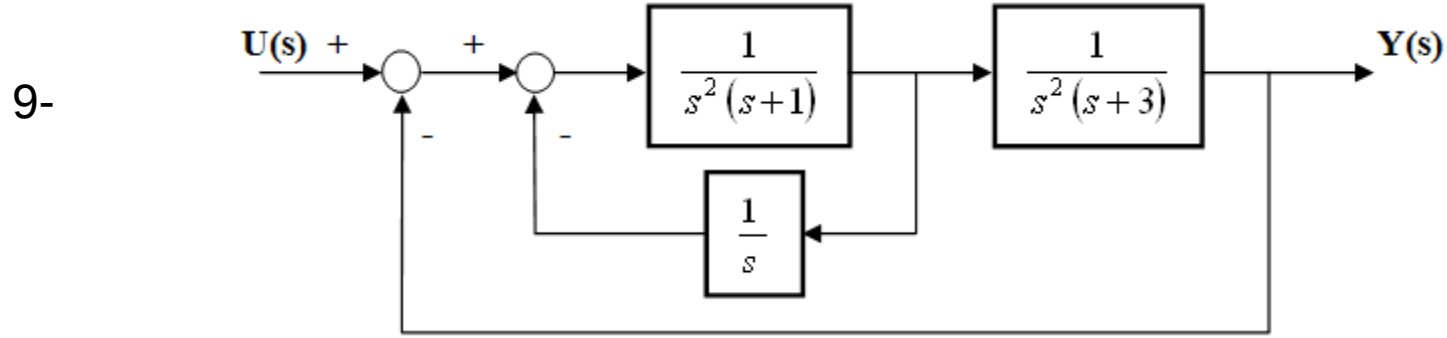
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Problemler:



# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

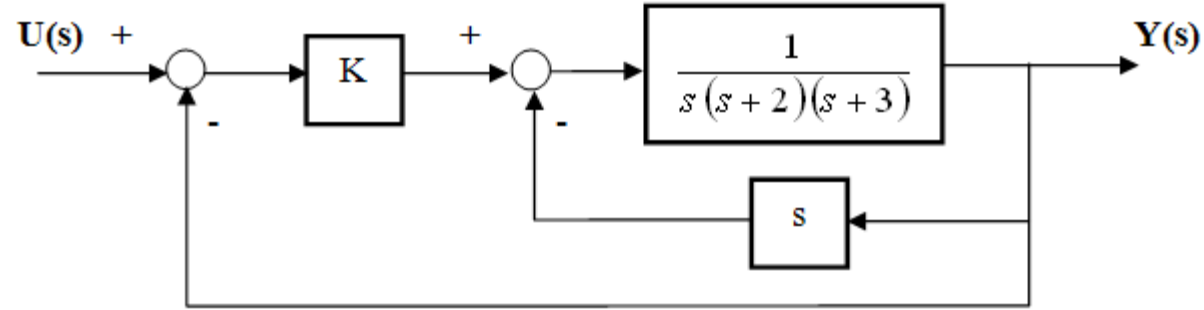
Problemler:



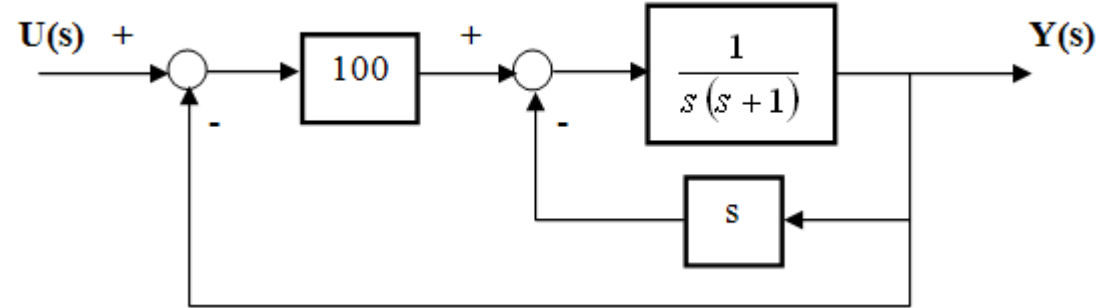
# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Problemler:

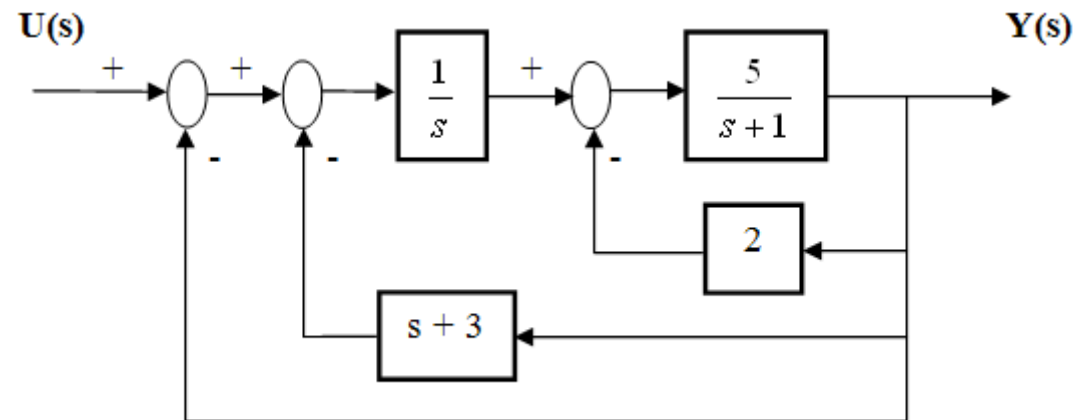
11-



12-

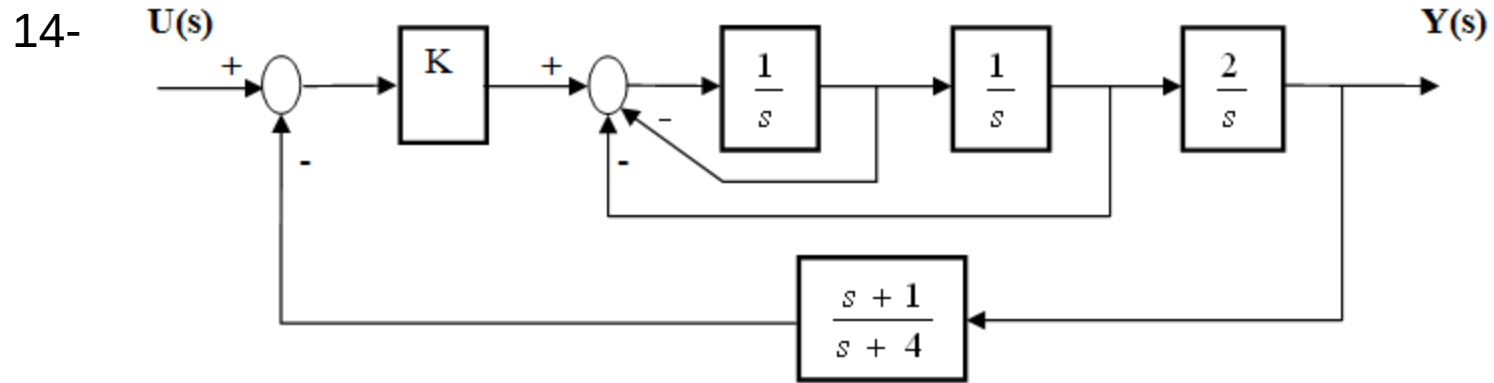


13-

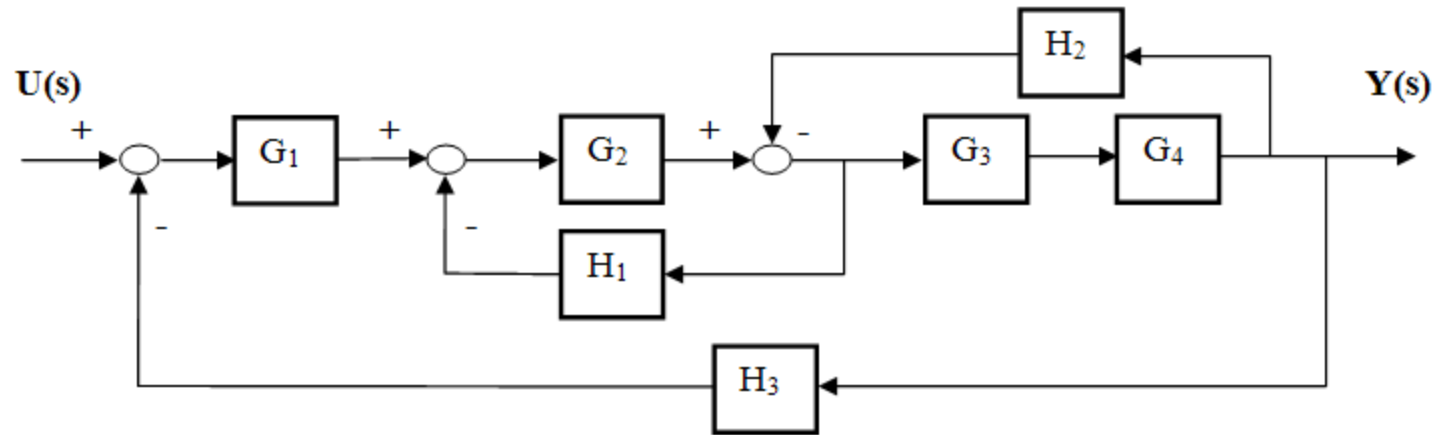


# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Problemler:

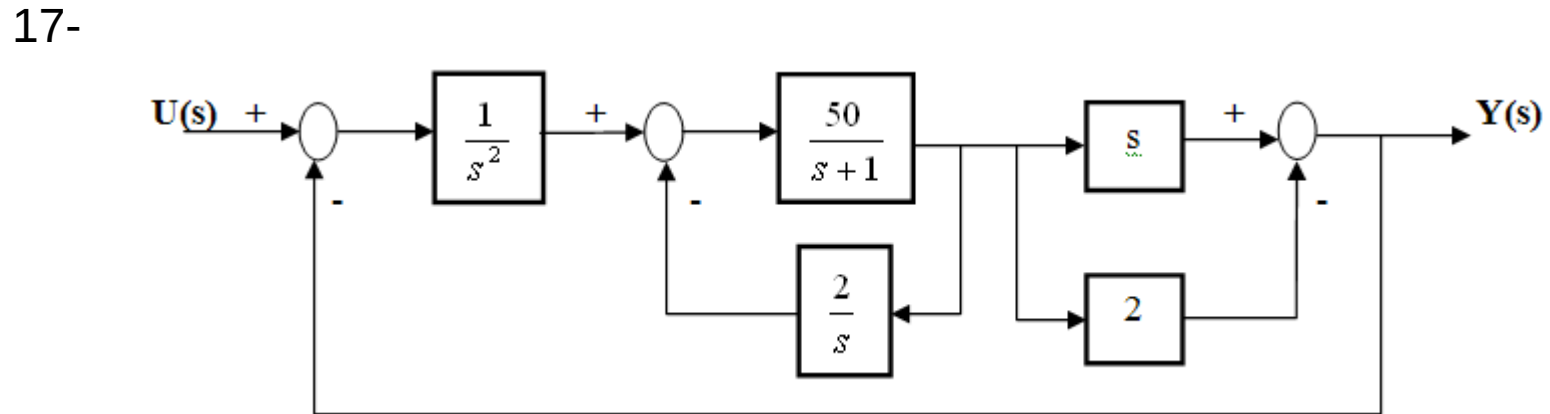
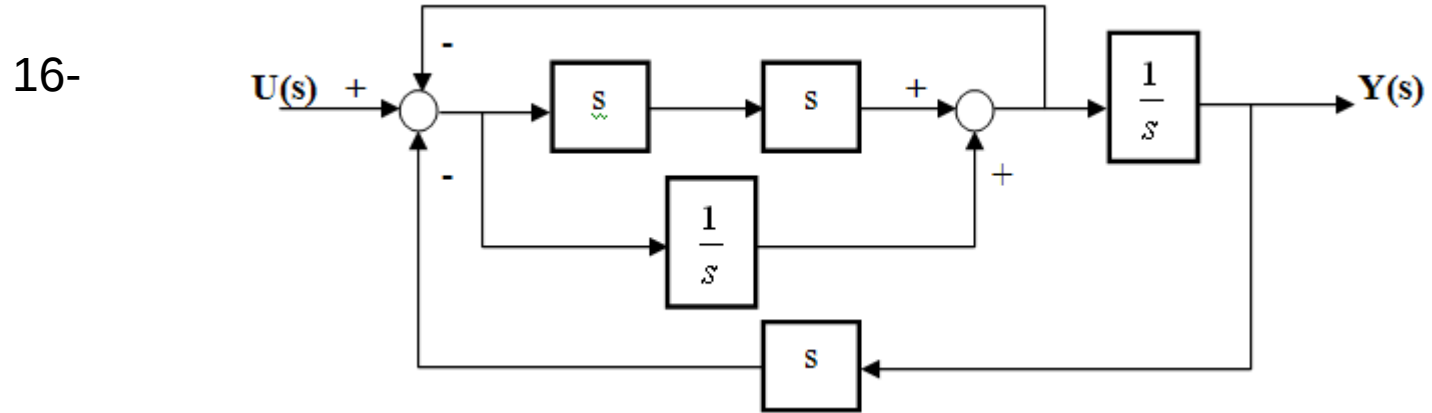


15-



# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Problemler:



# BLOK DİYAGRAMLARIN SADELEŞTİRİLMESİ İLE İLGİLİ ÖRNEK PROBLEMLER VE ÇÖZÜMLERİ

Problemler:

