Chapter 05

Block Diagram

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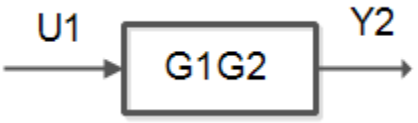
■ Block Diagram

- In many control systems, the system equations can be written so that their components do not interact except by having the input of a part be the output of another part
- In these cases, it is easy to draw a block diagram that represents the mathematical relationships in a manner similar to that used for the component block diagram
- The transfer function of each component is placed in a box
- And the I/O relationships between components are indicated by lines and arrows
- We can then solve the equations by graphical simplification which is often easier and more informative than algebraic manipulation

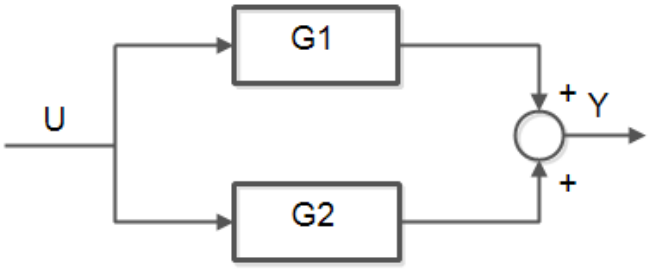
Series

$$U1 * G1 * G2 = Y2$$

$$\frac{Y2}{U1} = G1 * G2$$



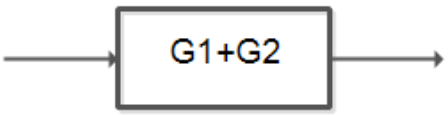
Parallel:



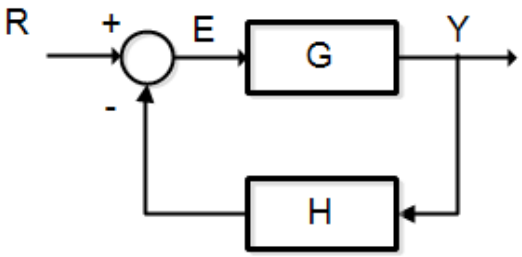
$U * G1 + U * G2 = Y$

$U(G1 + G2) = Y$

$\frac{Y}{U} = G1 + G2$



Feedback:



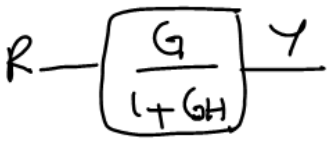
$$E = R - YH$$

$$EG = Y$$

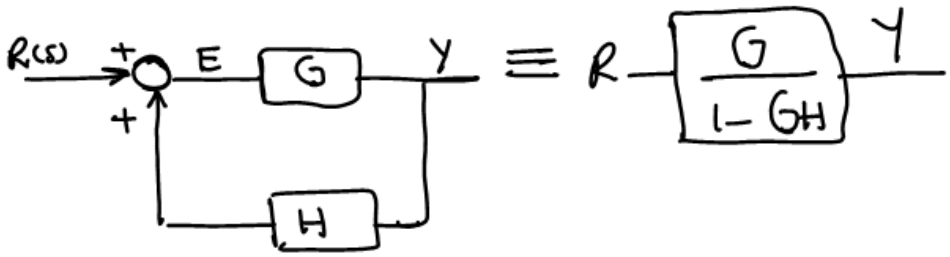
$$(R - YH)G = Y$$

$$RG = Y(1 + GH)$$

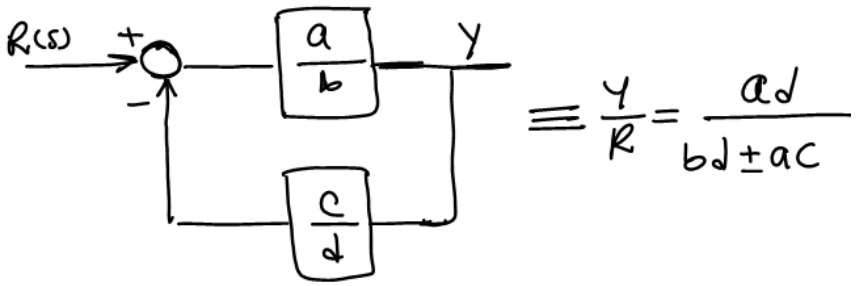
$$\frac{Y}{R} = \frac{G}{1 + GH}$$



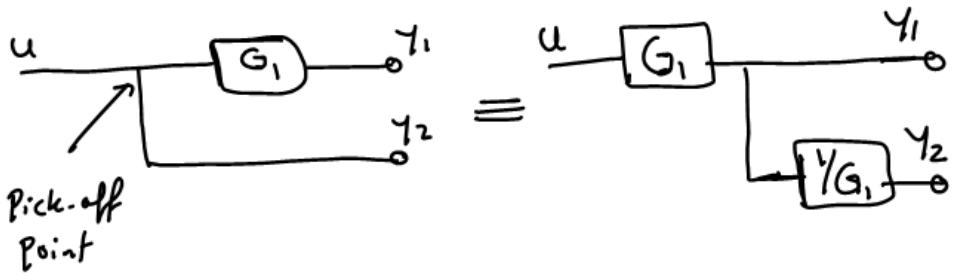
Similarly



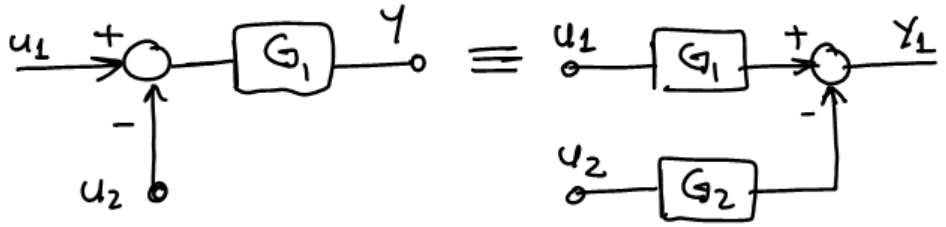
Hint:

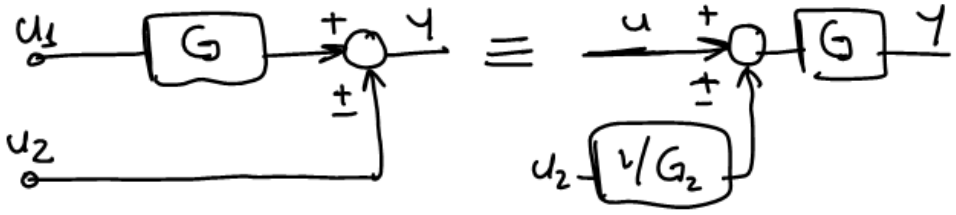


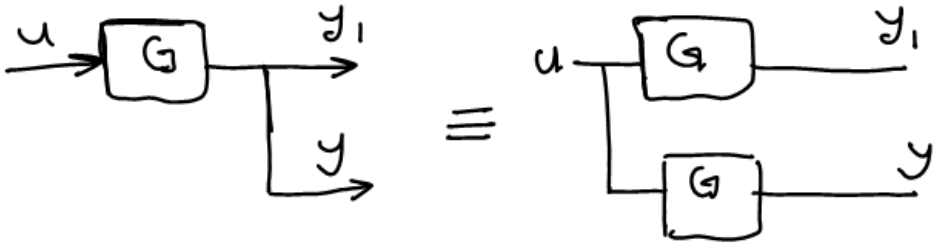
Note that:

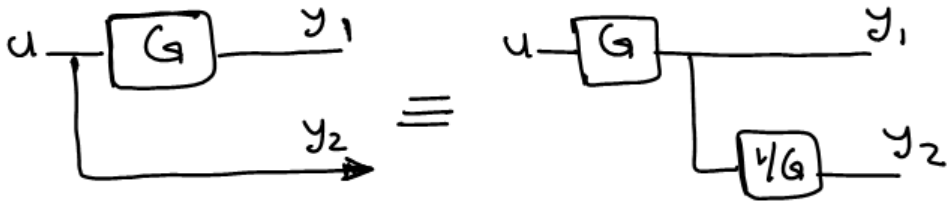


You can think of it as taking $G1$ as common factor or you want to move the pick-off point to the right



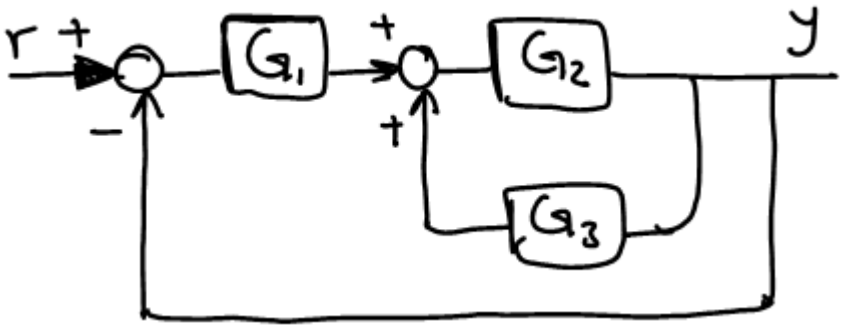


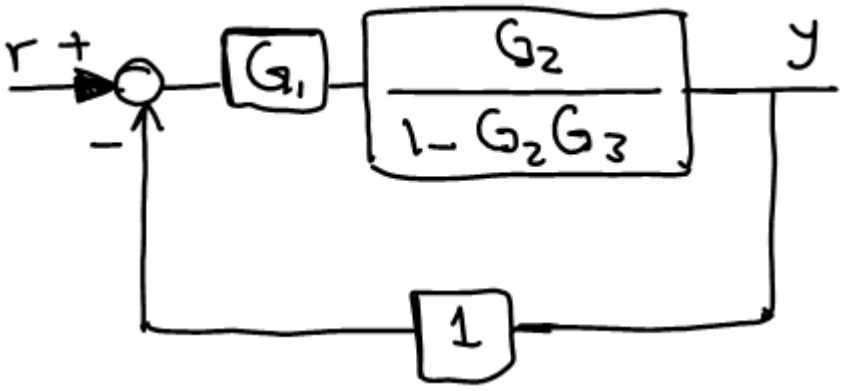


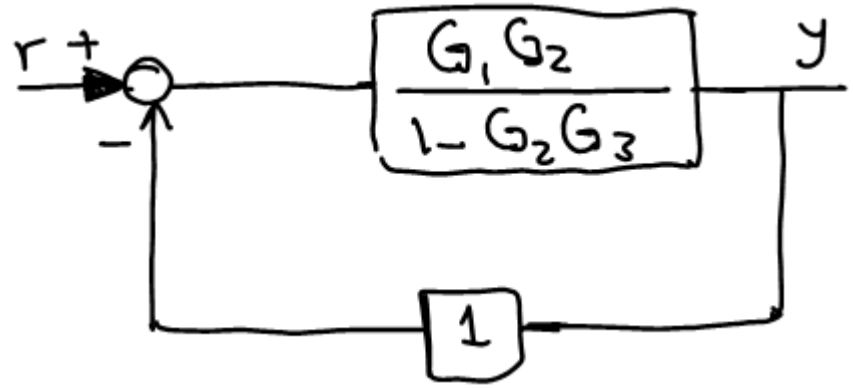


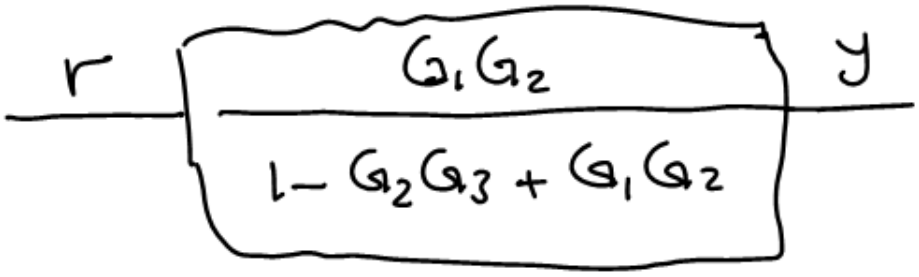
Example:

Find the transfer function Y/R



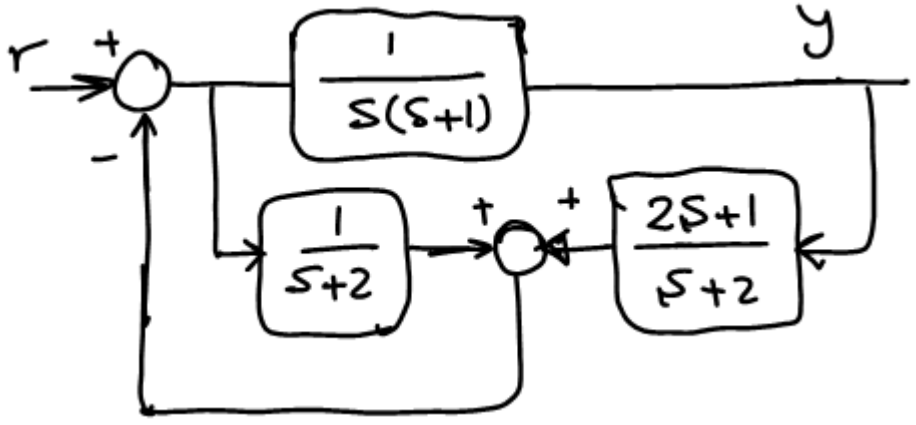


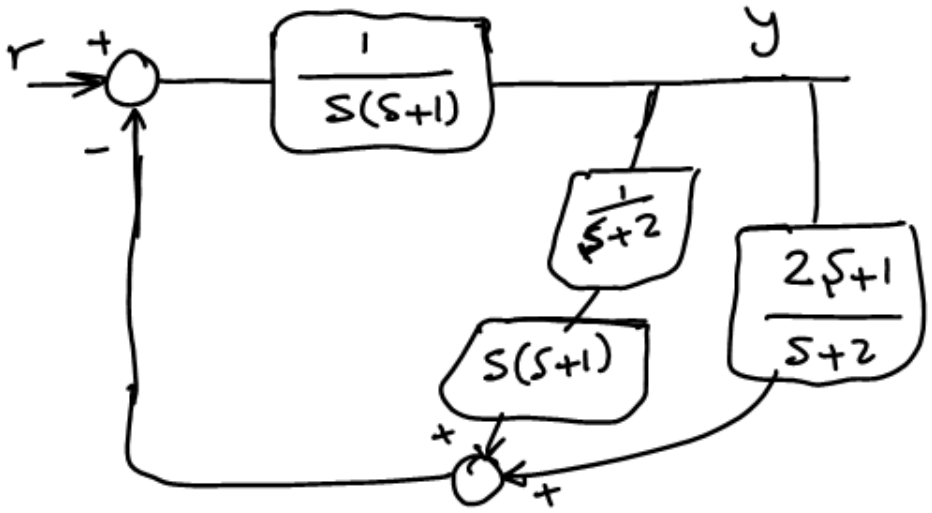


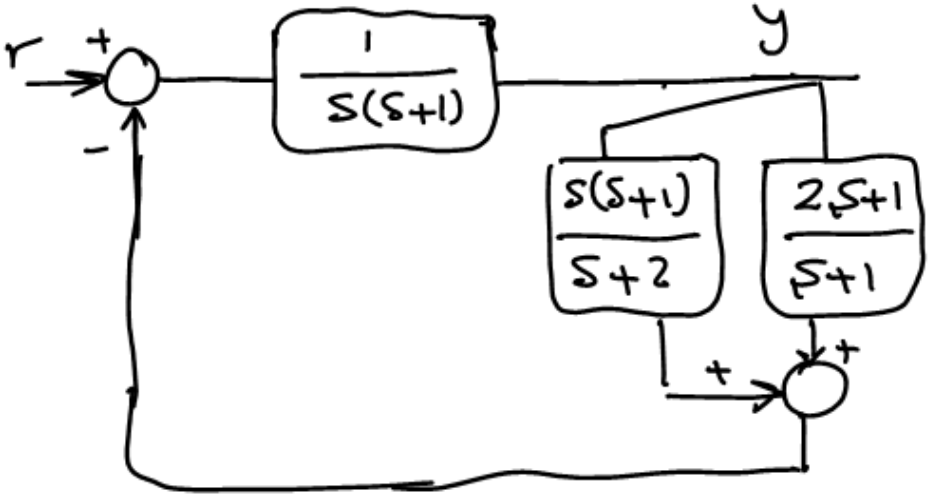


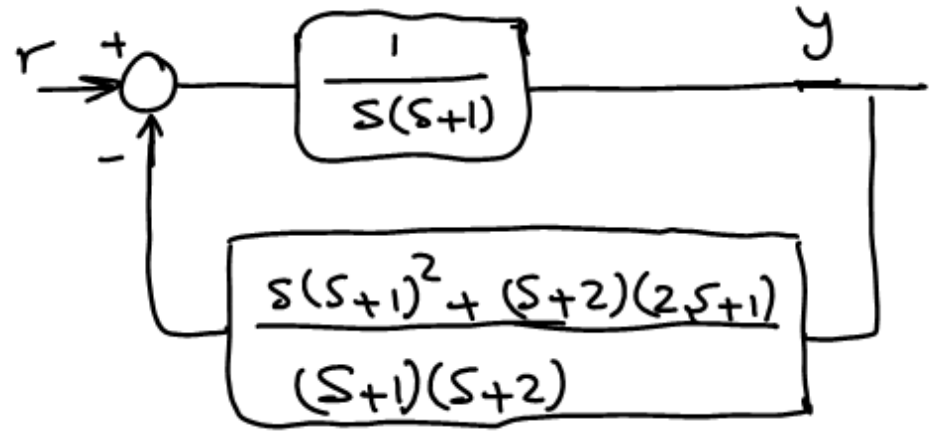
Example:

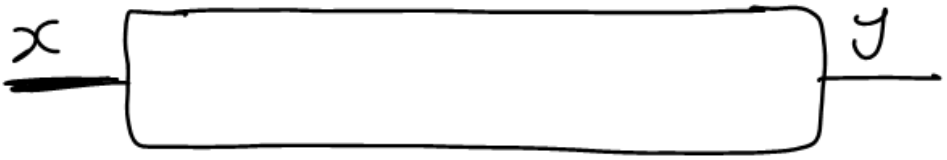
Find the transfer function Y/R



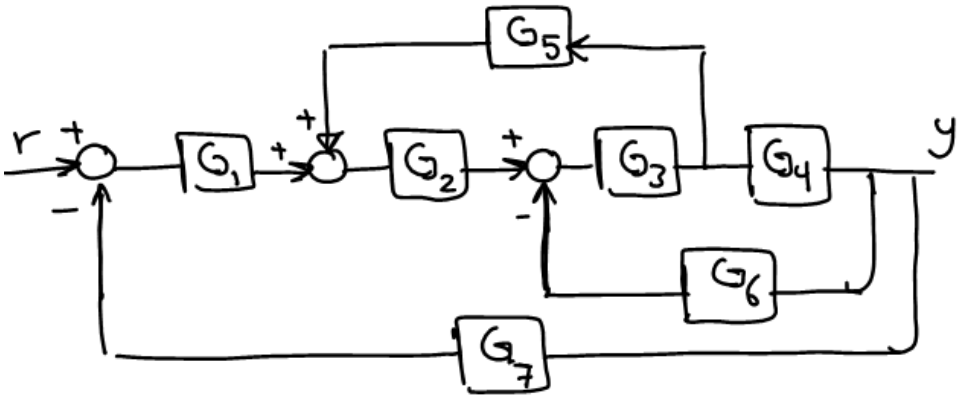

r
+
−
1
S(S+1)
y
1
S+2
S(S+1)
2S+1
S+2
+
+


r
+
−
1
S(S+1)
y
S(S+1)
S+2
2S+1
S+1
+
+



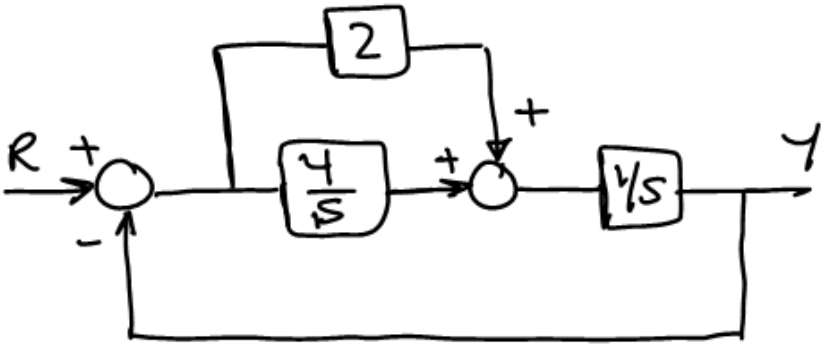


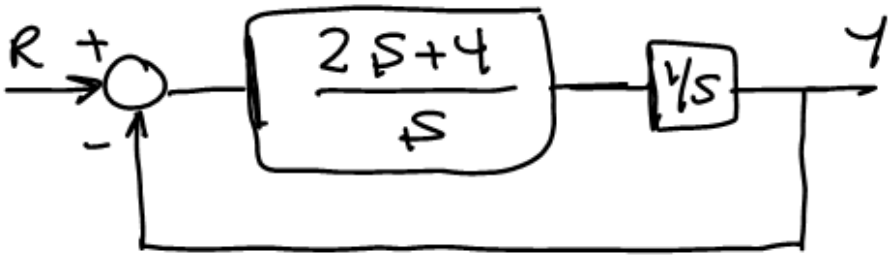
Problem:

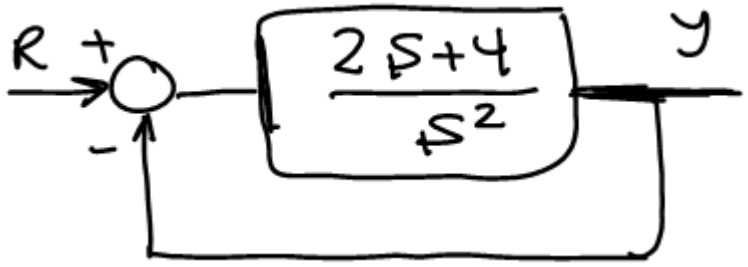


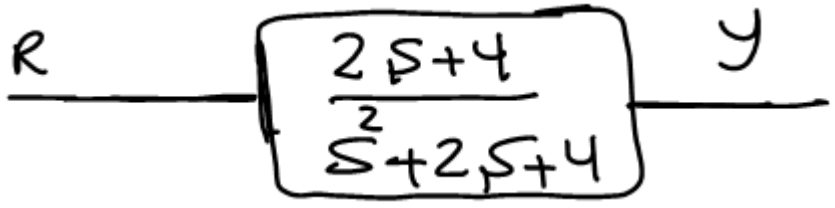
Example:

Find the transfer function of the system below





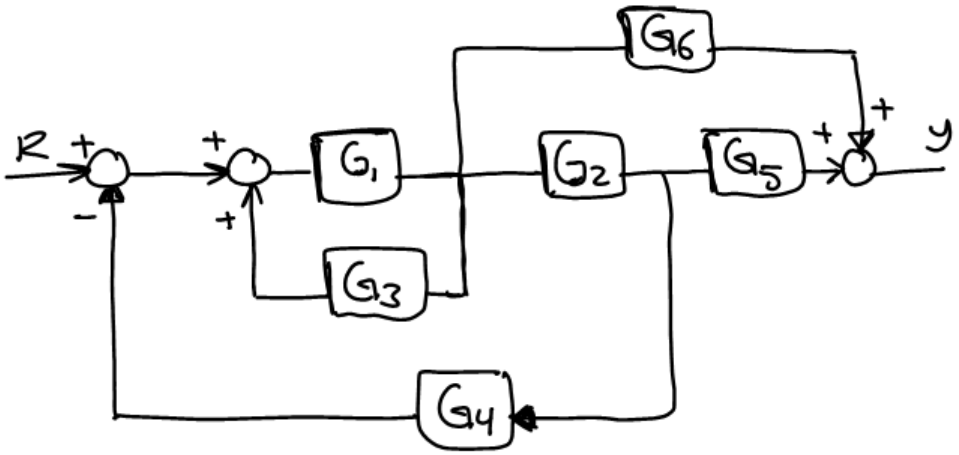


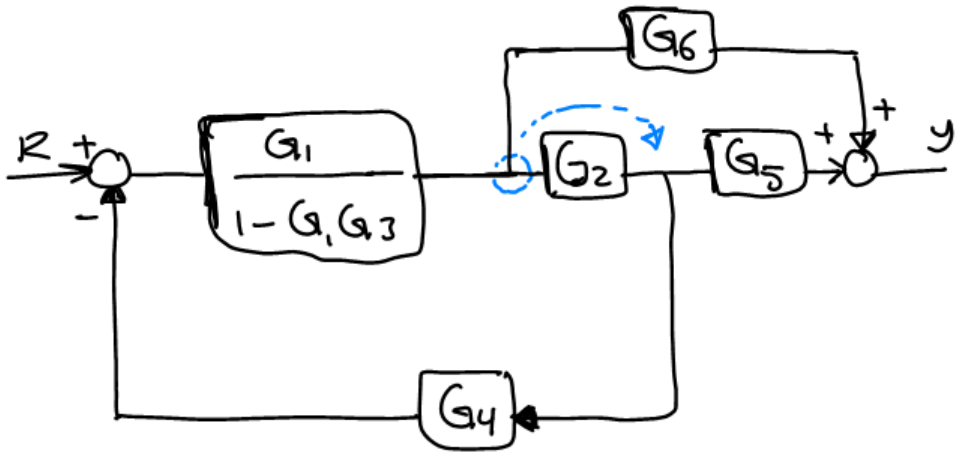


$$\frac{Y}{R} = \frac{2s + 4}{s^2 + 2s + 4}$$

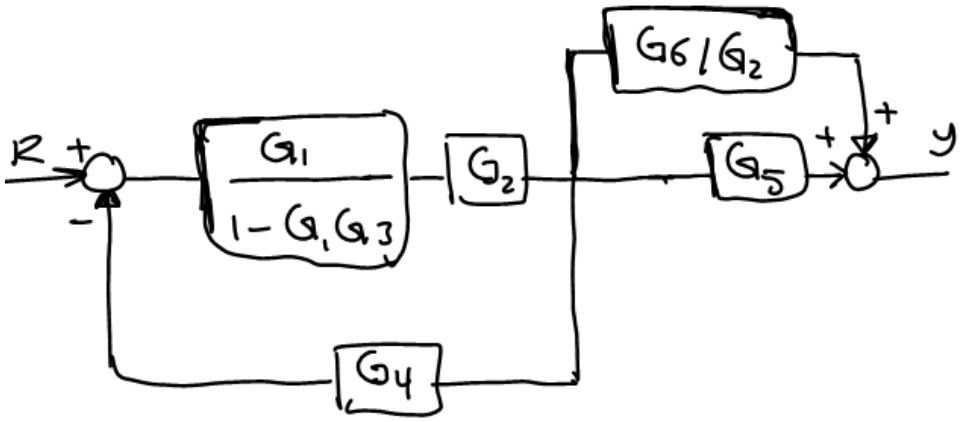
Example:

Find the transfer function of the system below





Move the pick off point preceding $G2$ to its output



Please continue to get

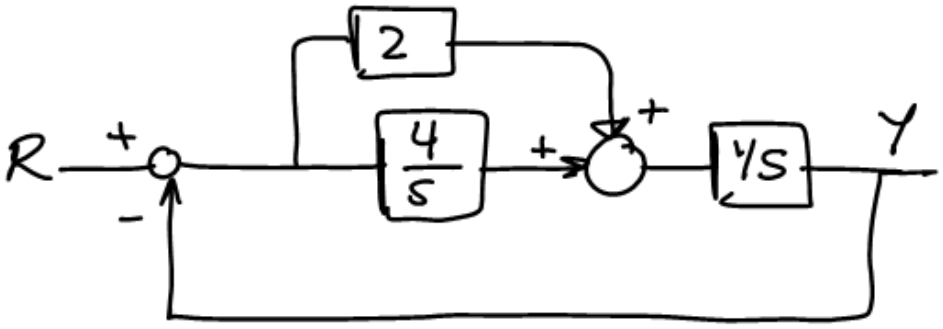
$$TF = \frac{G1\ G2\ G5 + G1\ G6}{1 - G1\ G3 + G1\ G2\ G4}$$

Block Diagram reduction using MATLAB

- Series
- Parallel
- Feedback

Example:

Find the transfer function of the system below using MATLAB




```
num = [2];
den = [1];
SysG1 = tf(num,den);
num = [4];
den = [1 0];
SysG2 = tf(num,den);
SysG3=parallel(SysG1,SysG2)
num = [1];
den = [1 0];
SysG4 = tf(num,den);
SysG5=series(SysG3,SysG4)
SysG6=feedback(SysG5,1)
```

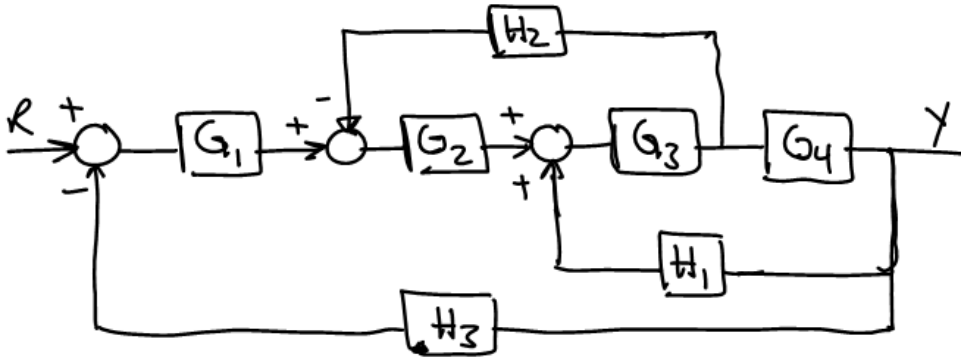
```
SysG6 =

     2 s + 4
  -------------
  s^2 + 2 s + 4

Continuous-time transfer function.
```

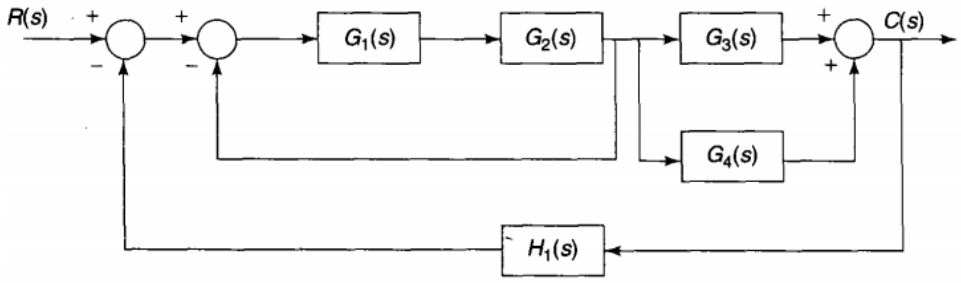
Problem:

Find the transfer function of the system below using MATLAB

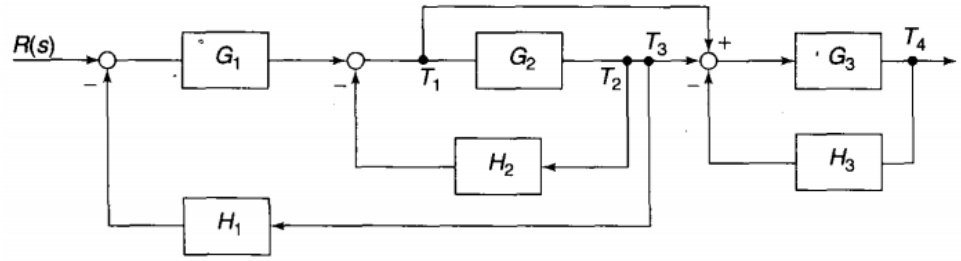


Problem:

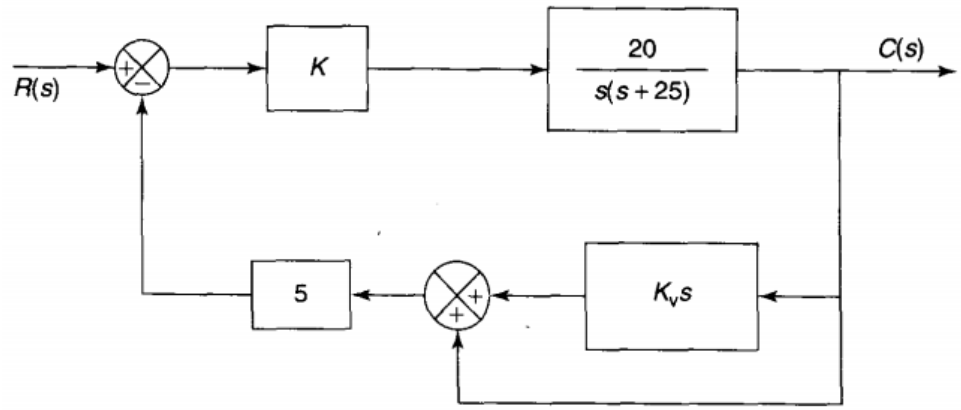
1. Reduce the system described below to a single block and determine the transfer function of that block



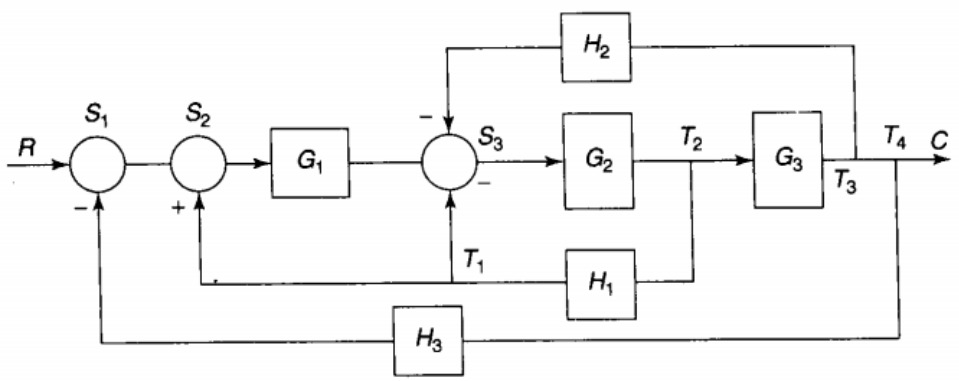
2. Find the transfer function



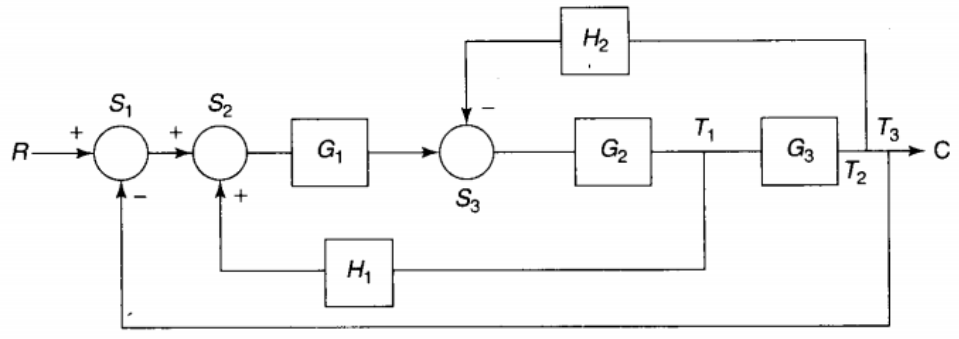
3. Find the transfer function



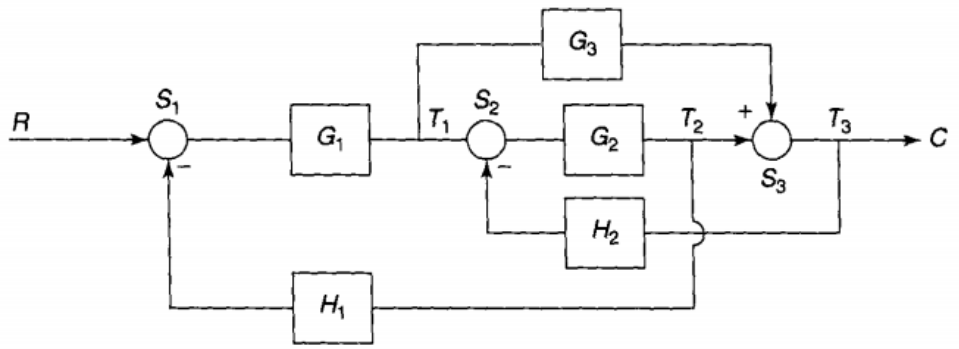
4. Simplify the block diagram for the system shown below and determine the closed-loop transfer function



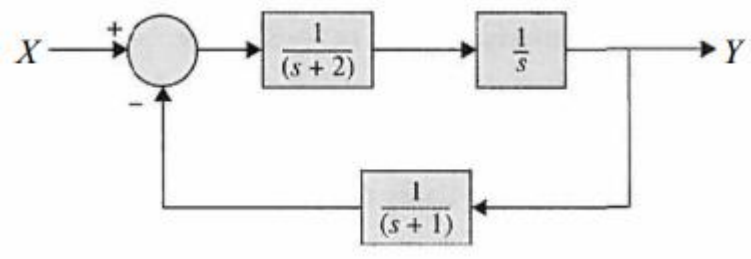
5. Obtain $C(s)/R(s)$



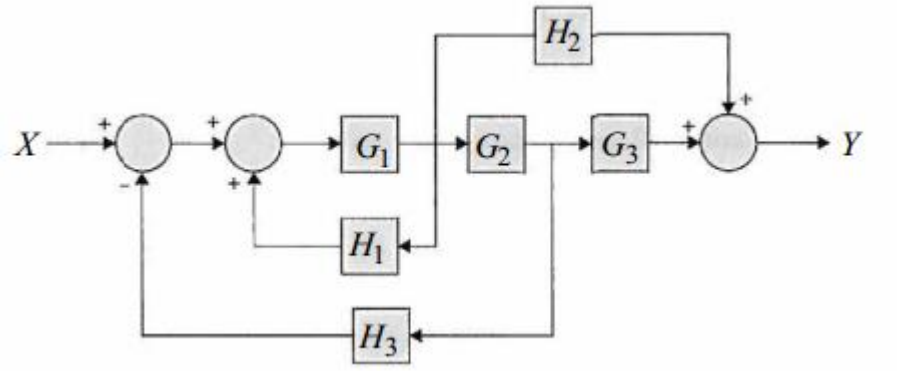
6. Reduce the block diagram shown below and obtain $C(s)/R(s)$



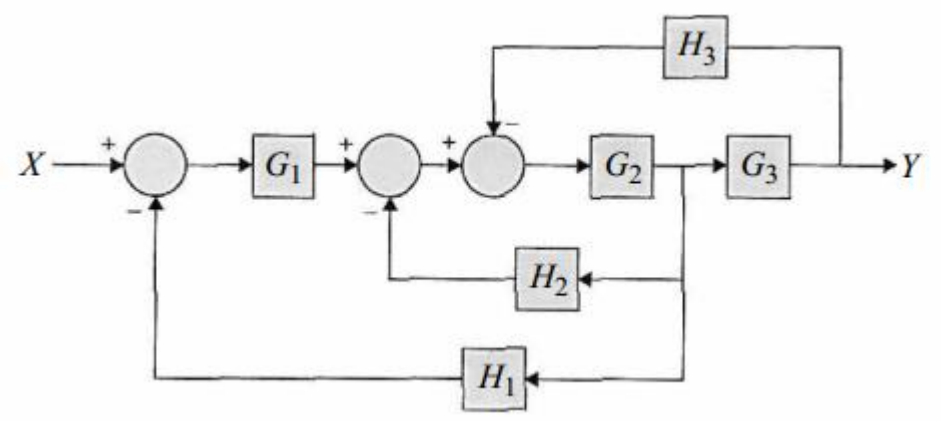
7. Reduce the block diagram shown below to unify feedback form and find the system **characteristic equation**



8. Reduce the block diagram shown and find Y/X



9. Reduce the block diagram shown and find Y/X



10. Find the output $Y(s)$ when $R(s)$ and $N(s)$ are applied simultaneously