08_assignment_signals_and_systems

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1 Hochschule Bonn-Rhein-Sieg

2 Mathematics for Robotics and Control SS17

3 Assignment 8: Signals and Systems

```
In [2]: import IPython.core.display
        import sys
        if not "win" in sys.platform and not "linux" in sys.platform:
            %pylab
        else:
            %pylab inline
```

```
Populating the interactive namespace from numpy and matplotlib
```

For this assignment, you can use a tool such as yEd or OpenOffice Draw to create block diagrams. Save them as images and include them in the notebook. Feel free to also hand-draw them and include scanned images.

3.0.1 ODEs to block diagrams (25 points)

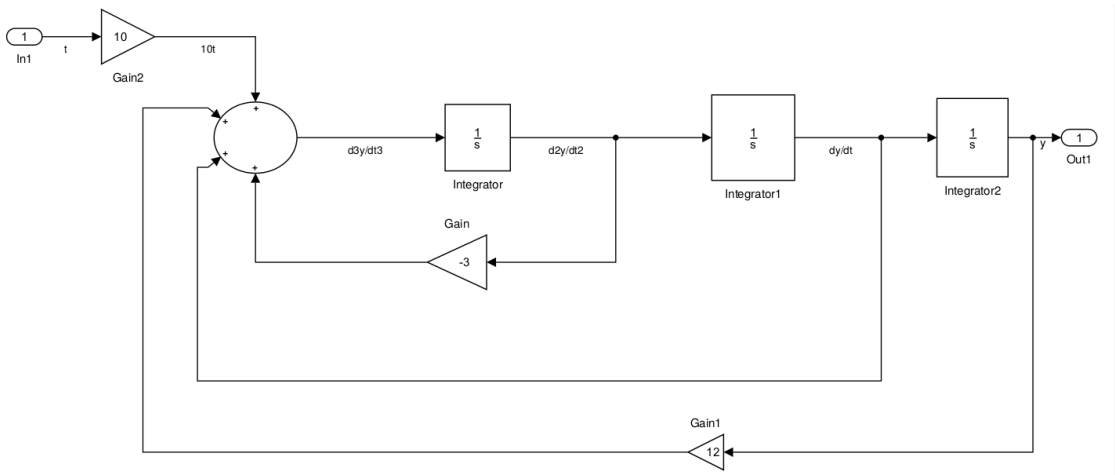
Represent the following ODE as a block diagram.

$$y''' + 3y'' - y' - 12y - 10t = 0$$

where y is the output and $10t$ is the input

```
In [8]: # You can include your solution as an image
        #IPython.core.display.Image("images/diagram_1.png", embed=True)
        IPython.core.display.Image("images/Answer1.png", embed=True)
```

Out[8]:



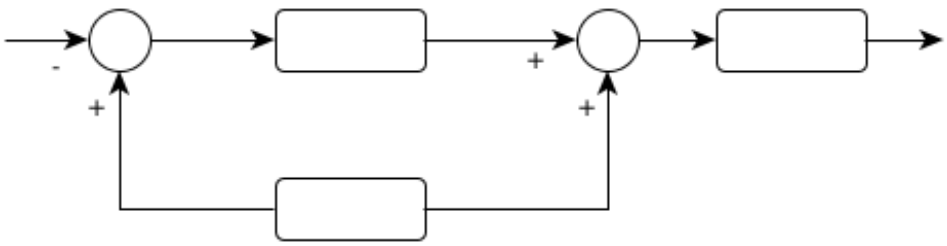
In the above figure, the input is t and output is y

3.0.2 Rules for block diagrams (15 points)

1. What (if anything) is wrong with the block diagrams below (i.e. what rule are they violating)?

```
In [6]: IPython.core.display.Image("images/diagram_1.png", embed=True)
```

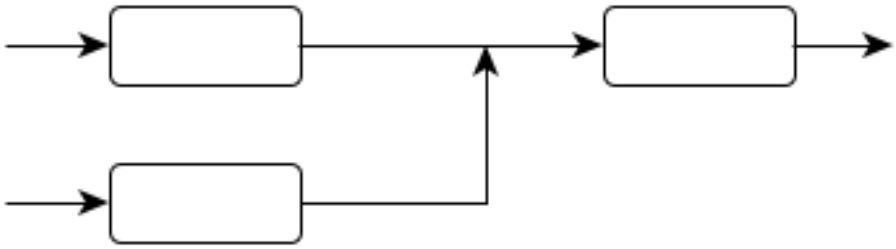
```
Out[6]:
```



Answer: No input and only outputs are present for the parallel block at the bottom.

```
In [7]: IPython.core.display.Image("images/diagram_2.png", embed=True)
```

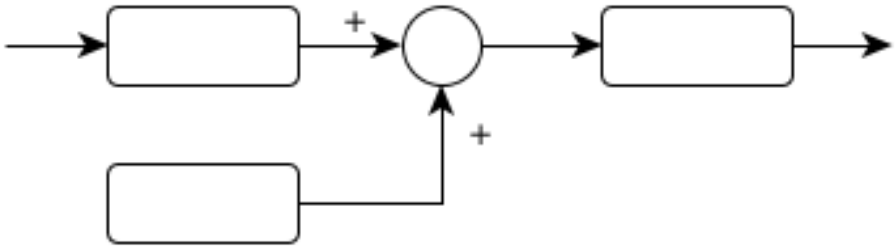
```
Out[7]:
```



Answer: Signal feeds another signal.

```
In [8]: IPython.core.display.Image("images/diagram_3.png", embed=True)
```

Out[8]:



Answer: No input for the block at the bottom.

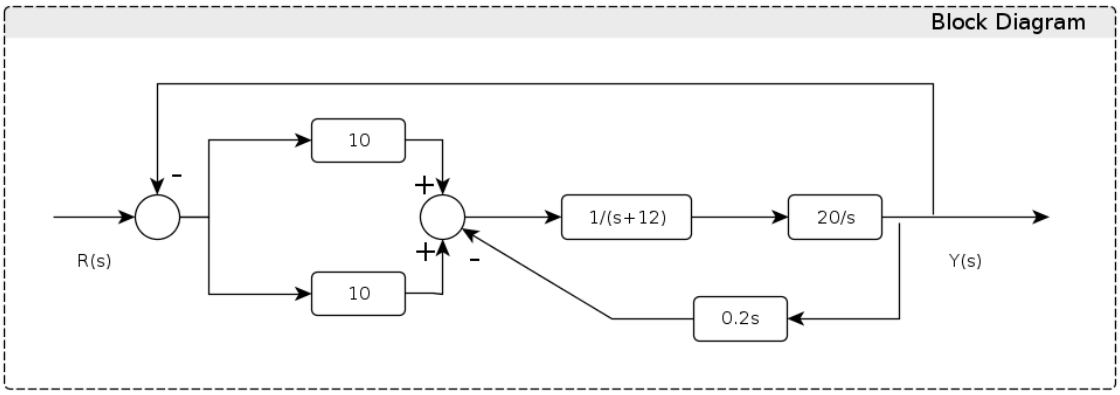
3.0.3 Simplification of block diagrams (40 points)

Simplify the following block diagrams and find the transfer function. Include intermediate steps and mention the rule you are using to simplify. For example:
$\frac{1}{s+12}$ and $\frac{20}{s}$ => $\frac{20}{s(s+12)}$ (blocks in series)
etc.

A)

```
In [9]: IPython.core.display.Image("images/block_diagram.png", embed=True)
```

Out[9]:

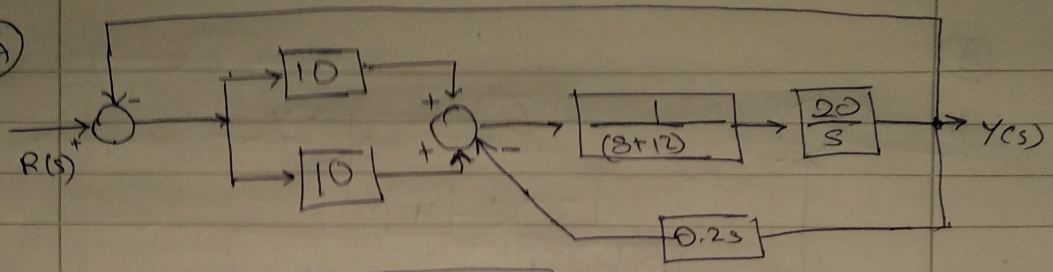


Your answer here:

```
In [17]: IPython.core.display.Image("images/Answer3A.jpg", embed=True)
```

Out[17]:

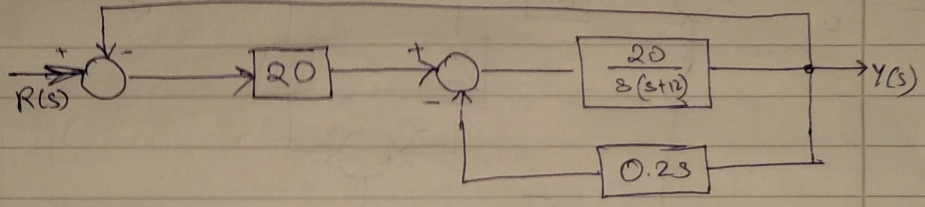
(A)



① 10, 10 ⇒ 20 (blocks in parallel)

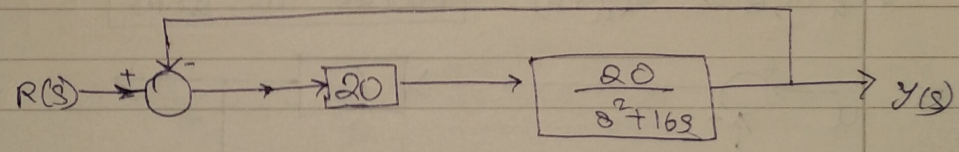
② $\frac{1}{s+12}, \frac{20}{s} \Rightarrow \frac{20}{s(s+12)}$ (blocks in series)

≡



③ $\frac{20}{s(s+12)}, 0.2s \Rightarrow \frac{20/s(s+12)}{1 + 0.2s \times \frac{20}{s(s+12)}} = \frac{20}{s^2+16s}$ (Fab back)

≡

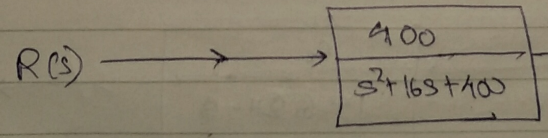


④ $20, \frac{20}{s^2+16s} \Rightarrow \frac{400}{s^2+16s}$ (blocks in series)

⑤ Also, a fab back of above is present, so,

$\frac{400}{s^2+16s}, 1 \Rightarrow \frac{400/(s^2+16s)}{1 + \frac{400}{s^2+16s}} = \frac{400}{s^2+16s+400}$

≡

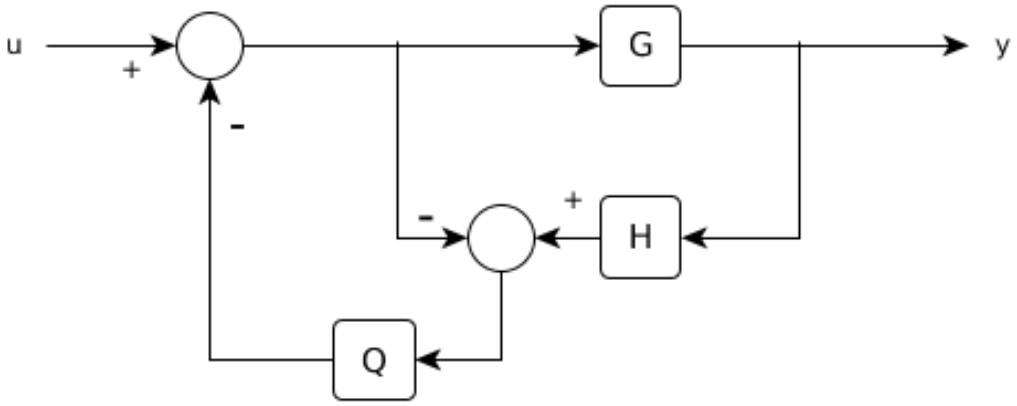


#

B)

```
In [10]: IPython.core.display.Image("images/diagram_4.png", embed=True)
```

Out[10]:

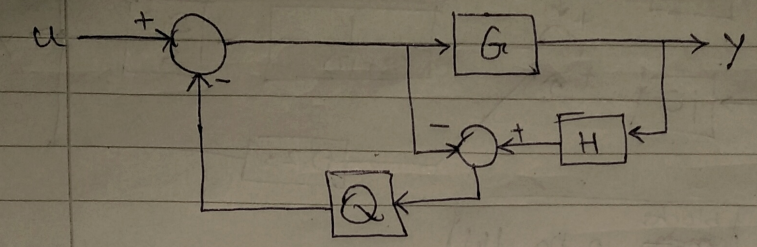


Your answer here:

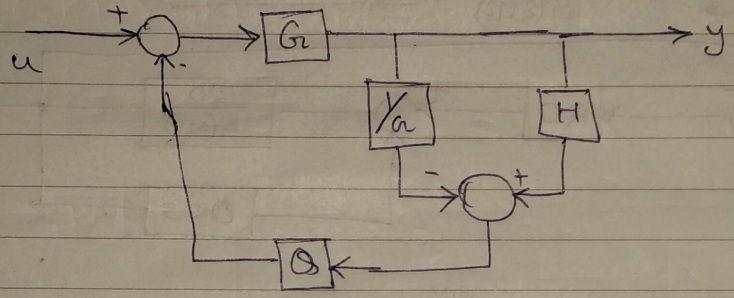
```
In [18]: IPython.core.display.Image("images/Answer3B.jpg", embed=True)
```

Out[18]:

(B)



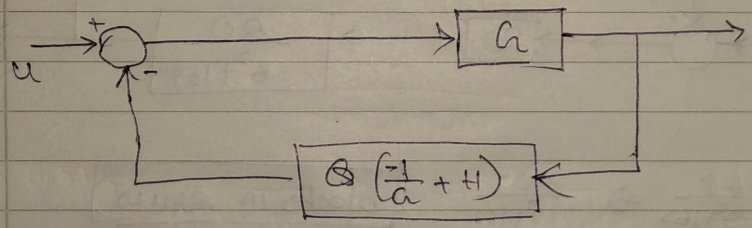
≡



$-1/G, H \Rightarrow -\frac{1}{G} + H$ — Blocks in parallel

& $\frac{-1}{G}+H, Q \Rightarrow Q\left(\frac{-1}{G}+H\right)$ — Blocks in series

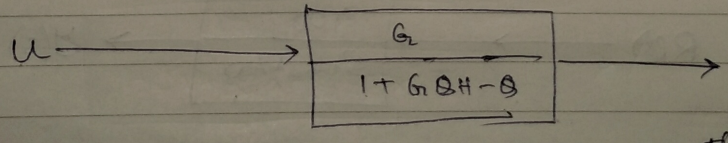
≡



$G, Q\left(H - \frac{1}{G}\right) \Rightarrow \frac{G}{1 + GQ\left(H - \frac{1}{G}\right)}$ — Feedback block

$= \frac{G}{1 + GQH - Q}$

≡

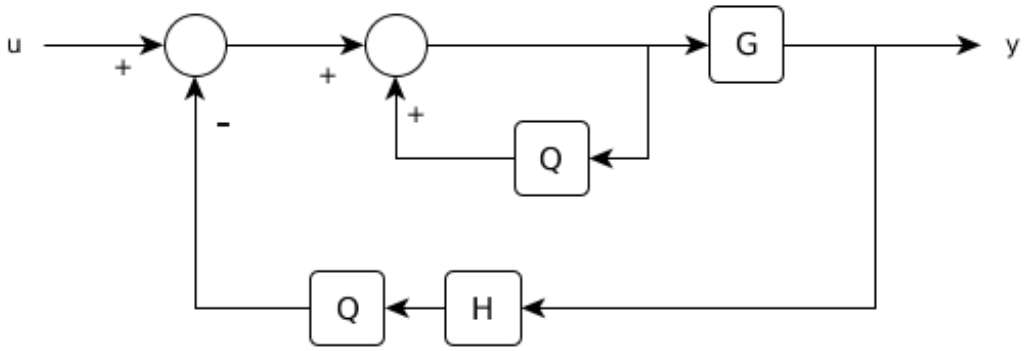


#

C)

```
In [15]: IPython.core.display.Image("images/diagram_5.png", embed=True)
```

Out[15]:

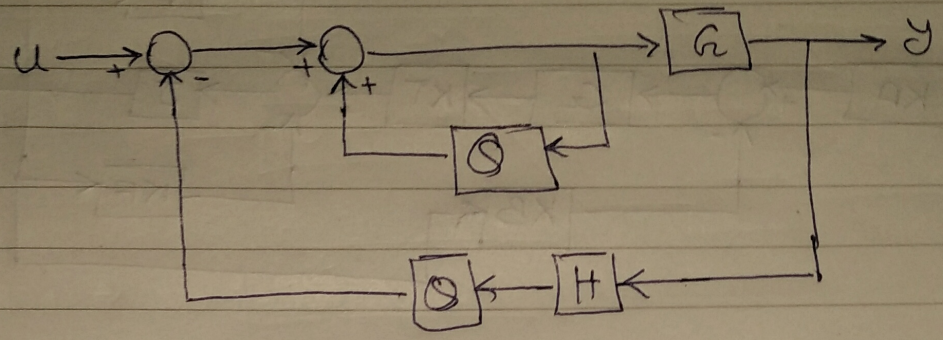


Your answer here:

```
In [19]: IPython.core.display.Image("images/Answer3C.jpg", embed=True)
```

Out[19]:

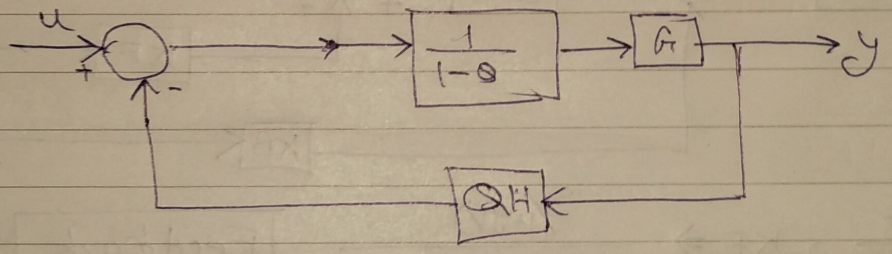
(c)



① $\Theta, H \Rightarrow \Theta H$ — Series block

② $-\Theta, 1 \Rightarrow \frac{1}{1-\Theta}$ — Feedback

$=$

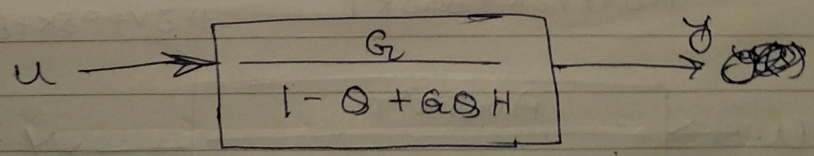


③ $G, \frac{1}{1-\Theta} \Rightarrow \frac{G}{1-\Theta}$ — Blocks in series

④ $\frac{G}{1-\Theta}, \Theta H \Rightarrow \frac{G/(1-\Theta)}{1+\frac{G\Theta H}{1-\Theta}}$ — Feedback

$$= \frac{G}{1-\Theta+G\Theta H}$$

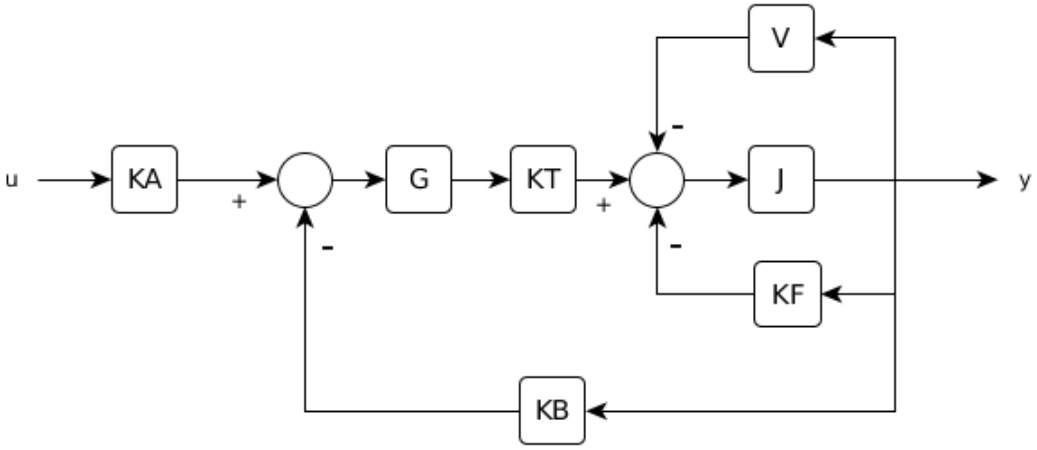
$=$



D) (from the lecture slides)

```
In [12]: IPython.core.display.Image("images/diagram_6.png", embed=True)
```

Out[12]:

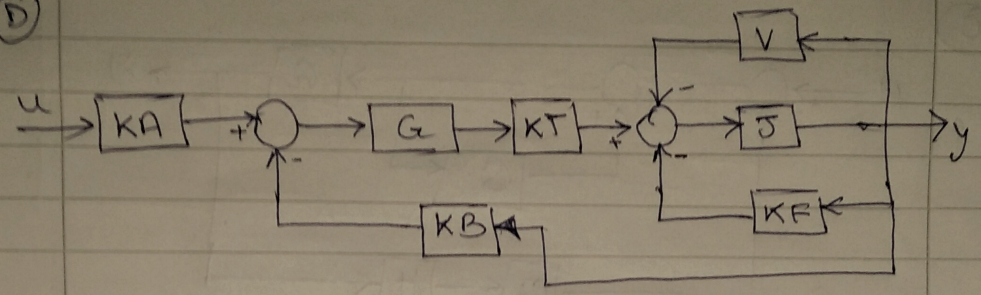


Your answer here:

```
In [20]: IPython.core.display.Image("images/Answer3D.jpg", embed=True)
```

Out[20]:

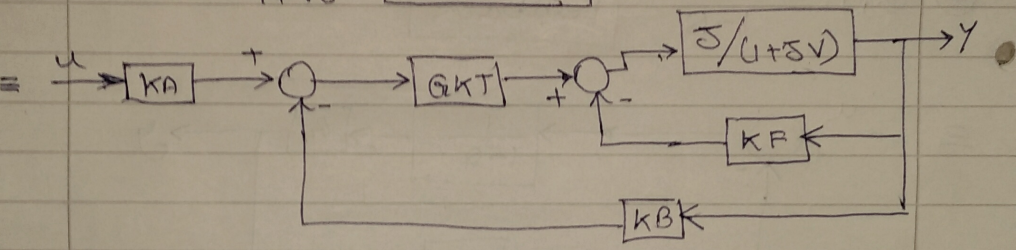
(D)



(1) $G, KT \Rightarrow GKT$ — Blocks in series

(2) $V, J \Rightarrow \frac{J}{1+VJ}$ — Feedback

$=$



(3) $\frac{J}{1+JV}, KF \Rightarrow \frac{\frac{J}{1+JV}}{1+\frac{J}{1+JV}(KF)}$ — Feedback

$= \frac{J}{1+JV+JKF}$

(4) $GKT, \frac{J}{1+JV+JKF} \Rightarrow \frac{GJKT}{1+JV+JKF}$ — Blocks in series

(5) $\frac{GJKT}{1+JV+JKF}, KB \Rightarrow \frac{GJKT}{1+JV+JKF+GJK^2TB}$ — Feedback

(6) $KA, \frac{GJKT}{1+JV+FJK+BGJK^2T} \Rightarrow \frac{AGJK^2T}{1+JV+FJK+BGJK^2T}$ — Blocks in series

$=$ u → $\frac{AGJK^2T}{1+JV+FJK+BGJK^2T}$ → Y

#