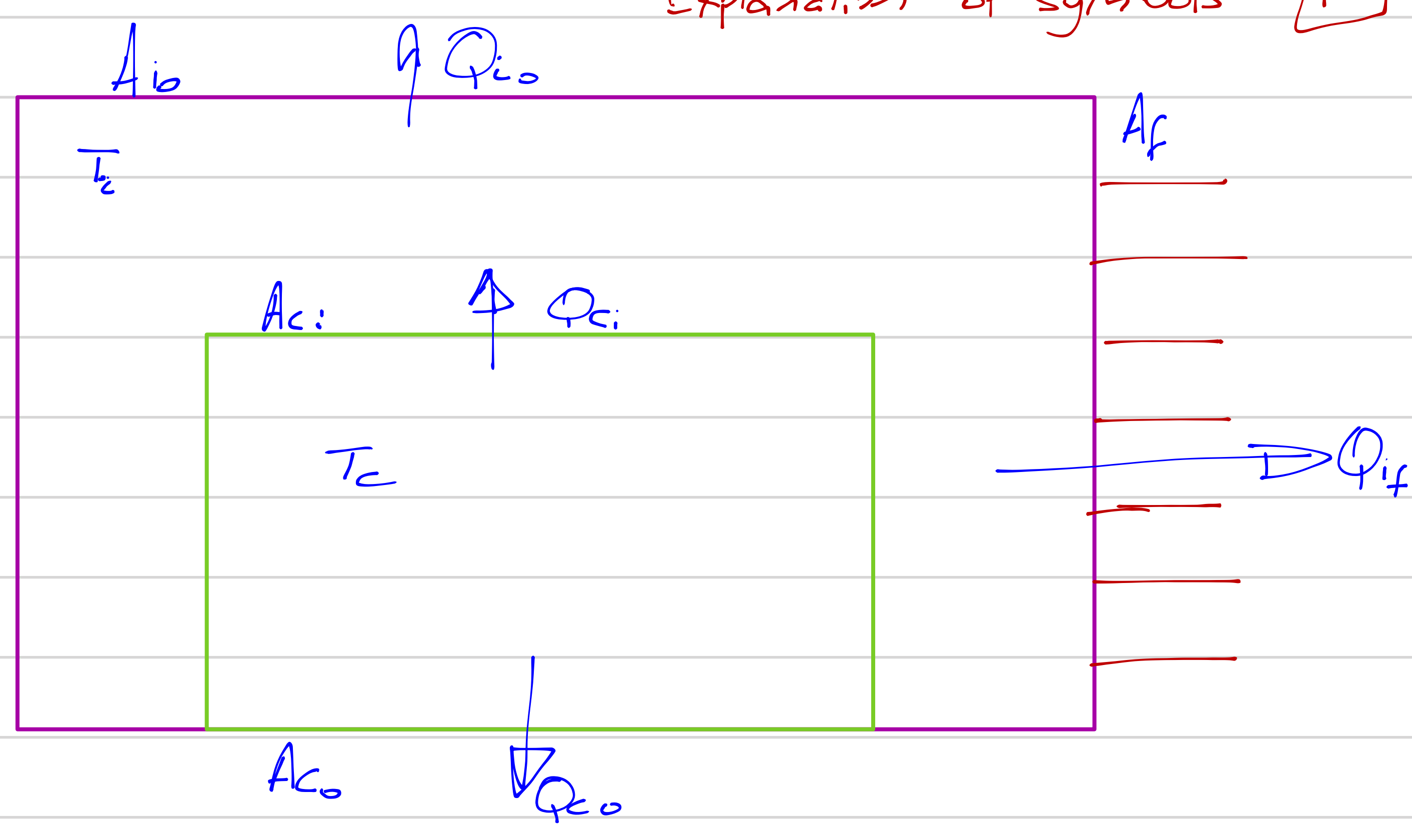
Modelling

Q①

Explanation of symbols $\boxed{10}$



Assume only lumped balances $\boxed{2}$

1) $\frac{dE_c}{dt} = Q_e - Q_{ci}$ $\boxed{2}$
2) $dE_i/dt = Q_{ci} - (Q_{if} + Q_{io} + Q_{co})$ $\boxed{4}$
3) $E_c = f_1(T_c)$ $\boxed{2}$
4) $E_i = f_2(T_i)$ $\boxed{2}$
5) $Q_{io} = h_{io} A_{io} (T_i - T_\infty)$ $\boxed{2}$
6) $Q_{ci} = h_{ci} A_{ci} (T_c - T_i)$ $\boxed{2}$
7) $Q_{co} = h_{co} A_{co} (T_c - T_\infty)$ $\boxed{2}$
8) $Q_{if} = h_f A_f (T_f - T_\infty)$ $\boxed{2}$
9) $h_f = f_3(Q_{if})$ $\boxed{4}$
10) $Q_e = f_4(\text{network load})$ $\boxed{4}$

Layout : $\boxed{2}$

Q(2)

INPUTS	Parameters	Outputs
Network load	h_{io}	E_c
Q_f	A_{io}	Q_c
T_∞	h_{ci}	Q_{ci}
	A_{ci}	E_{ci}
	h_{co}	Q_{if}
	A_{co}	Q_{io}
	A_f	Q_{co}
		T_c
		T_i
		h_f
3 ✓	7 ✓	10 ✓

$\boxed{5}$

Q(3) Total symbols : 20 $\boxed{✓}$
Minus equations : − 10 $\boxed{✓}$
Degrees of freedom : 10 DoF $\boxed{✓✓}$ $\boxed{5}$

Specifying inputs + paramaters completely specifies $\boxed{✓}$

Q(4) For feedback control, we measure the controlled variable and manipulate a variable that affects it. We will measure T_c $\boxed{2}$ and manipulate Q_f. $\boxed{2}$ T_∞ and the network load would be disturbances $\boxed{1}$

② Simulation and Linear Analysis

$$y(t) = w(t) - u(t)\log_{10}[z(t)]$$

$$\frac{dy}{dt} = g(t) - c\,g(t)$$

$$\frac{dg}{dt} = \sin(t+1)\,z(t) - y(t)$$

1) $c=3$, $w(0)=1$ and $g(0)=2$

@ steady state $\frac{dy}{dt}=0$ and $\frac{dg}{dt}=0$ $\boxed{1}$

$\rightarrow y(0) = w(0) - u\log z = 1 - u\log z$

$\Rightarrow \frac{dy}{dt} = 0 = g(0) - c\,y(0) = 2 - 3y(0) \Rightarrow y(0) = 2/3$

$\Rightarrow \frac{dg}{dt} = 0 = \sin(0+1)\,z(0) - y(0) \Rightarrow \sin(1)z = 2/3$

$$z = \frac{2}{3\sin(1)} \simeq 0{,}792$$

but $y = 1 - u\log z = 2/3$

$$u = \frac{1-2/3}{\log\left(\frac{2}{3\sin(1)}\right)} \simeq -3{,}296$$

Solution: $\boxed{2}$

Process: $\boxed{3}$

2) $$y'(t) = w'(t) - \underbrace{\log_{10}\bar{z}}_{a}\, u'(t) - \frac{\overbrace{\bar{u}}^{b}\, z'(t)}{\bar{z}\ln(10)}$$

$$\frac{dy'}{dt} = g'(t) - c\,y'(t)$$

$\boxed{10}$

$$\frac{dg'}{dt} = \overbrace{\sin(1)}^{d}\, z'(t) - y'(t)$$

Q3 $\mathcal{L}\{\}$: $Y(s) = W(s) + a\,U(s) + b\,Z(s)$

$$\Rightarrow Z_s = \frac{1}{b}\left[Y(s) - W(s) - a\,U(s)\right] \quad \text{eq } 1$$

$$sY(s) = G(s) - c\,Y(s) \quad \text{-- eq } 2$$

$$\Rightarrow Y(s) = \frac{1}{s+c} G(s)$$

$$sG(s) = d\,Z(s) - Y(s)$$

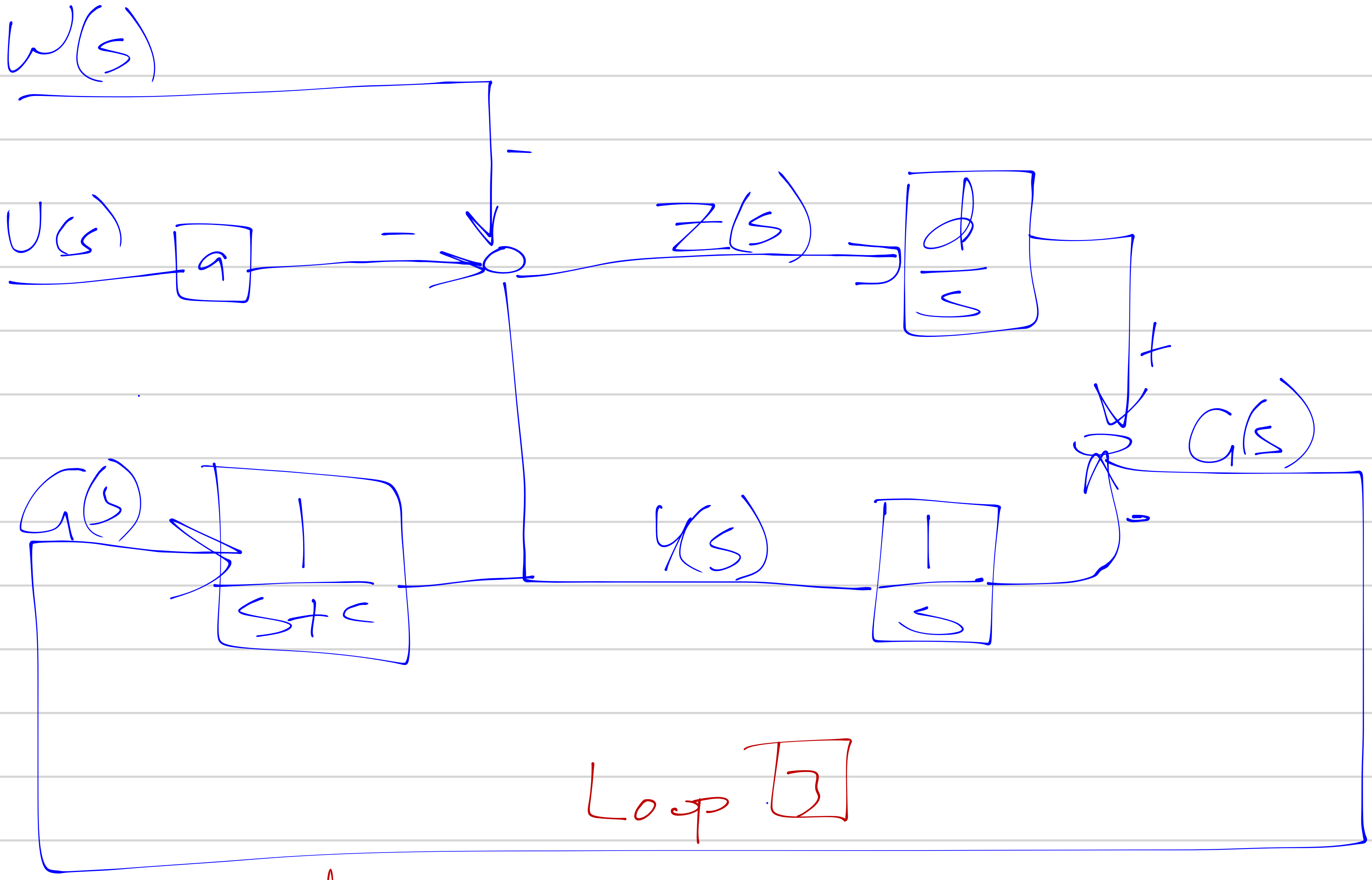
$$G(s) = \frac{d}{s} Z(s) - \frac{1}{s} Y(s) \quad \text{— eq } 3$$

eq 1 into 3: $G(s) = \frac{d}{sb} Y(s) - \frac{d}{sb} W(s) - \frac{da}{sb} U(s)$ -- eq 4

eq 2 into 4: $G(s) = \frac{d}{sb(s+c)} G(s) - \frac{d}{sb} W(s) - \frac{da}{sb} U(s)$

$$G(s) = \boxed{\frac{-1\,d}{\left(1 - \frac{d}{sb(s+c)}\right)}}\, W(s) - \boxed{\frac{d\,a}{\left(- \;-\; \frac{d}{sb(s+c)}\right)sb}}\, U(s)$$

$\boxed{10}$



Block → 3

Line → 2

inputs → 2