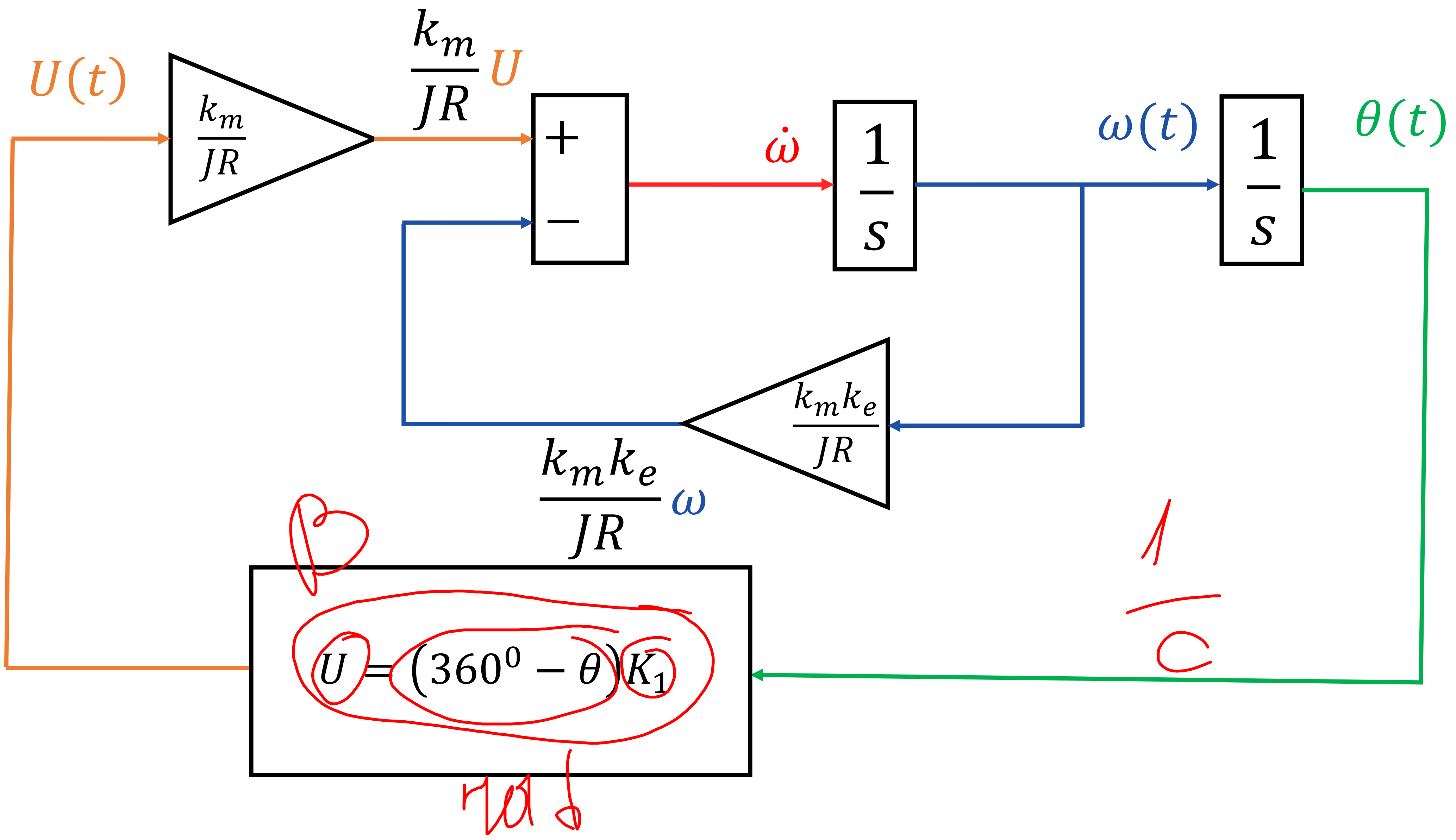
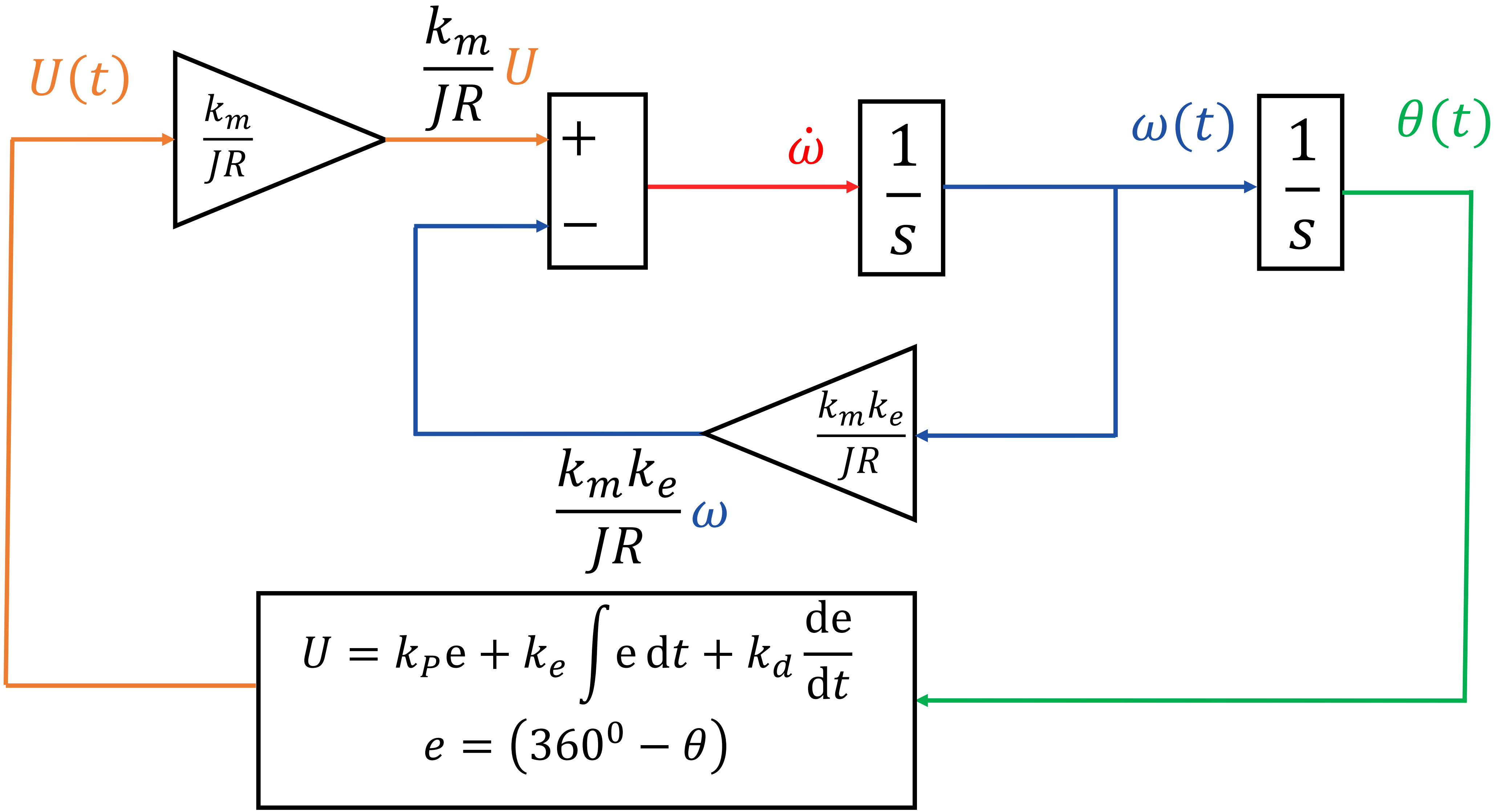
PID Controller

Aleksandr Kapitonov, 2020

Proportional controller with a coefficient

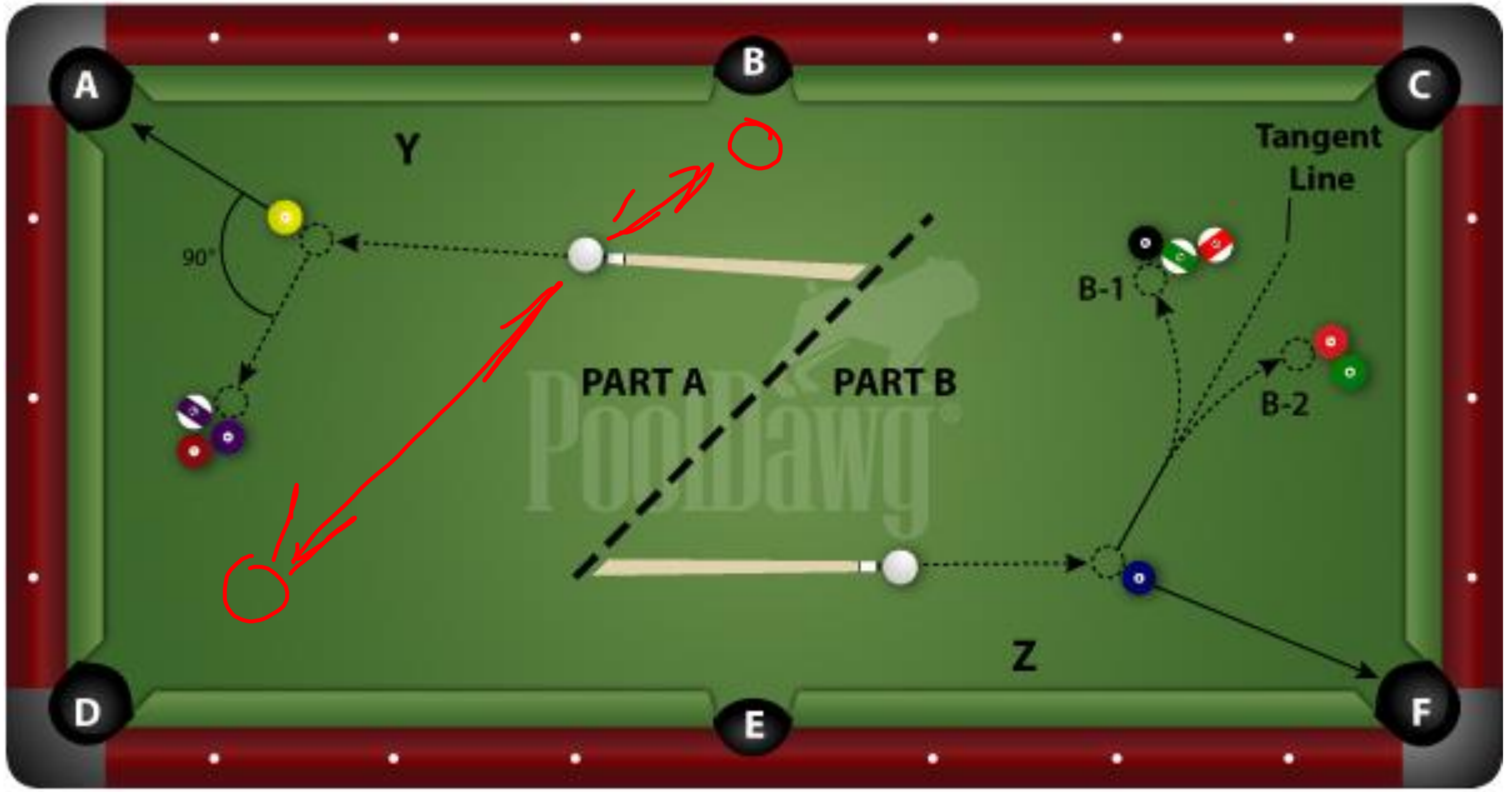


PID controller is not so complex



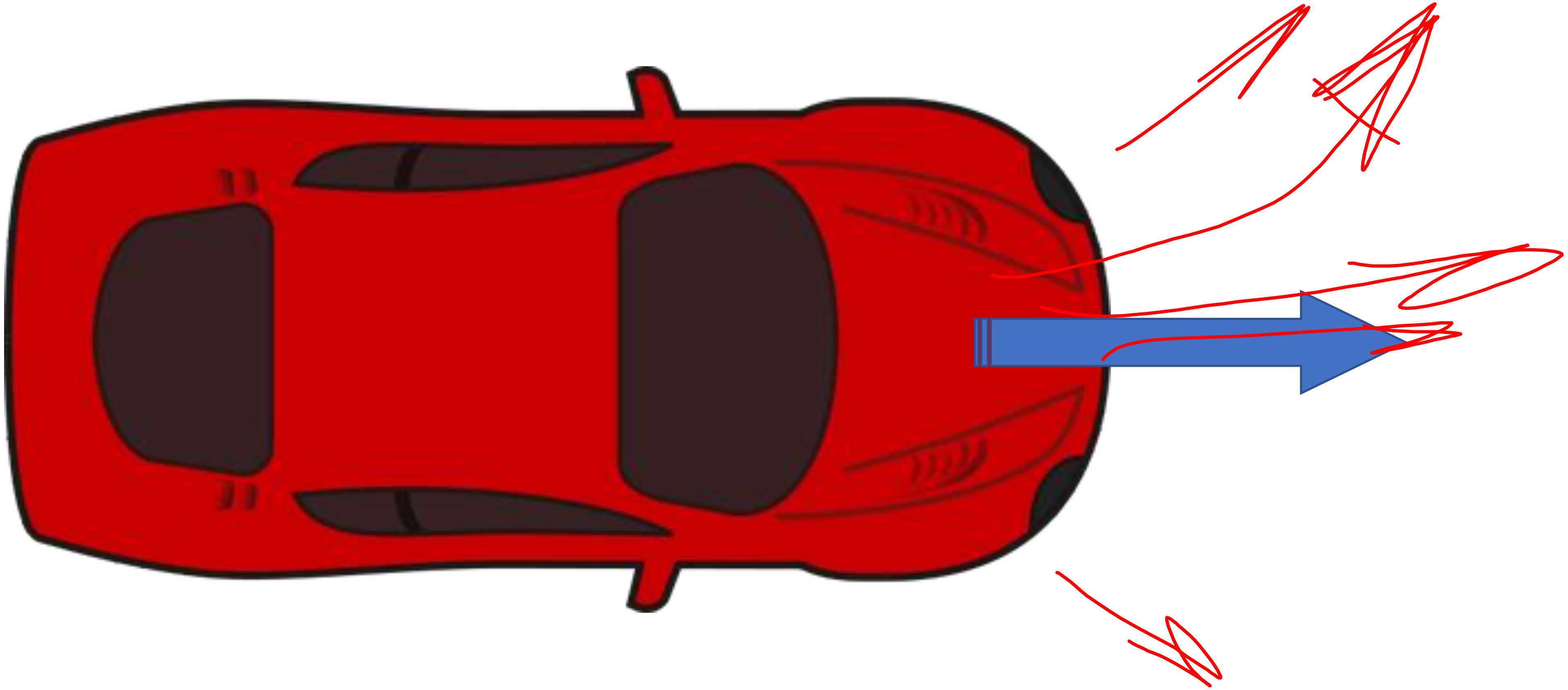
Borase, Rakesh P., et al. "A review of PID control, tuning methods and applications."

How do we feel a P-part?

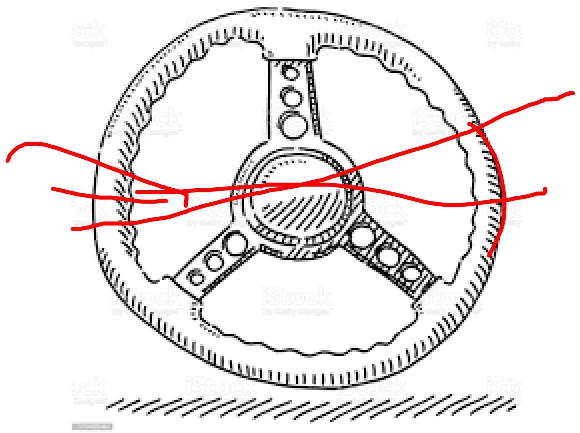


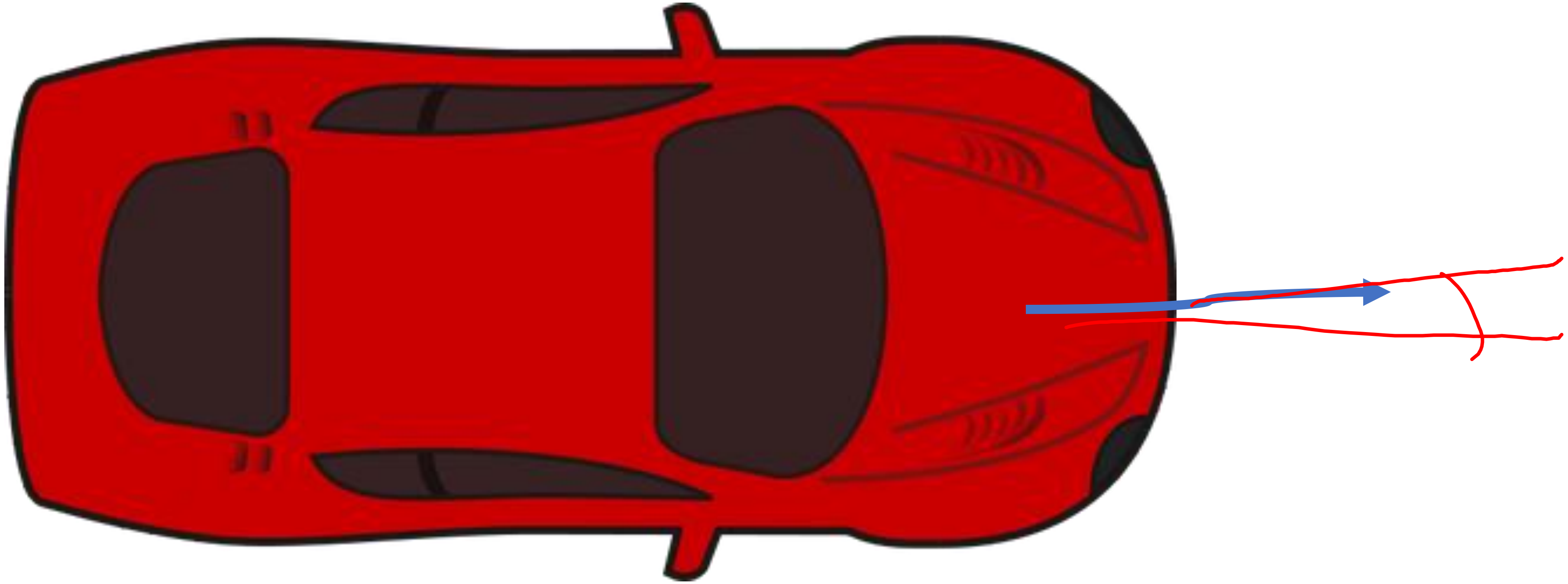
Additional link: [A heuristic-based planner and improved controller for a two-layered approach for the game of billiards]

How do we feel a D-part?

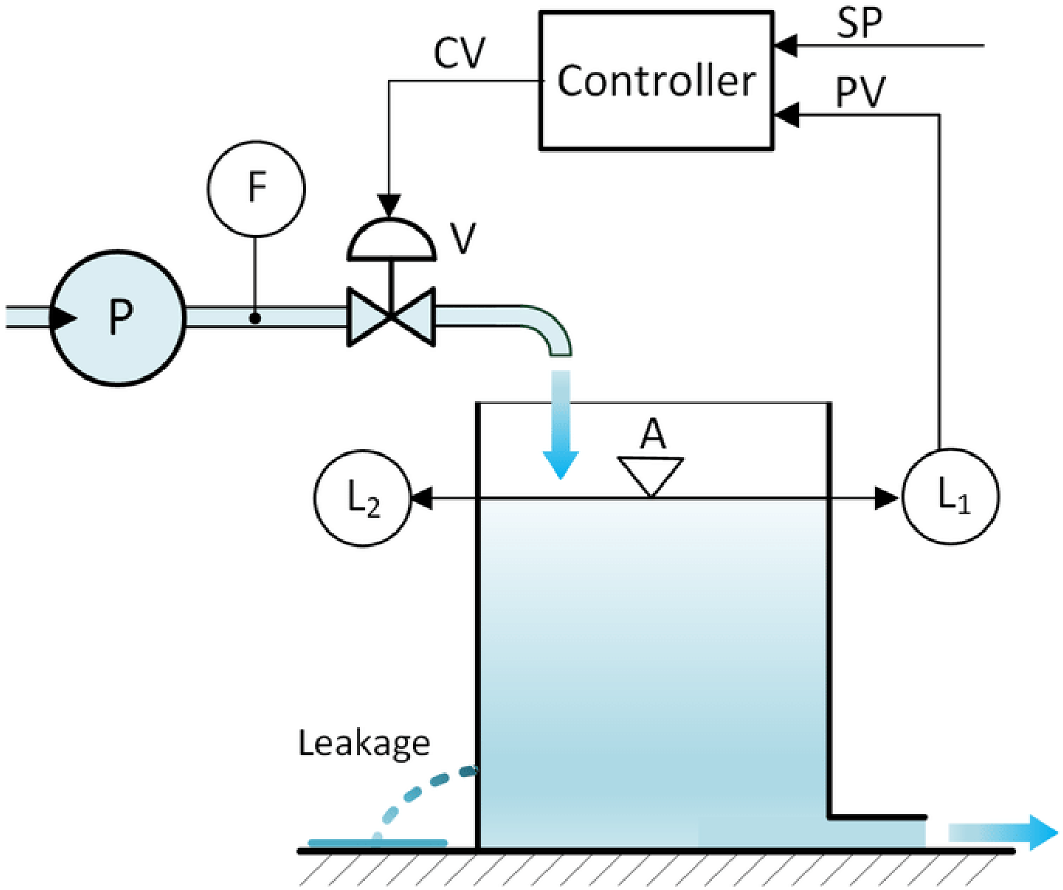


How do we feel an I-part?





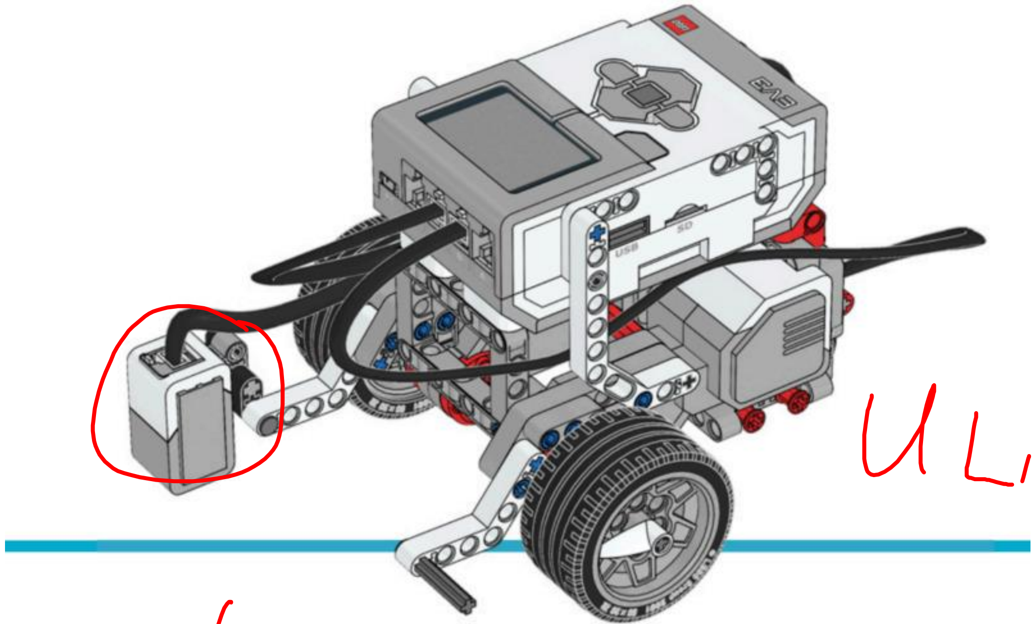
Where is P-controller is enough?



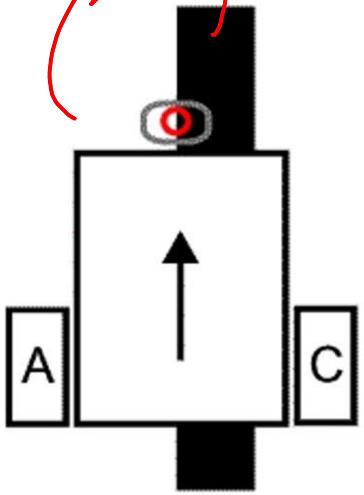
Additional link: [Common Industrial Applications of P-Only Control]()

Useful for PD-controller and mobile robots

$$u_R = 100\% \, ? \left(\frac{B+W}{2}\right)$$



When a vehicle follows the line, it actually is following edge of the line. Because if it follows the line directly(the black) then when it drifts off the line and the sensor "sees white“, it doesn't know which side of the line it is on.



$$u_L = 100\% \, ?$$

$$u_R = 100 + \left(\frac{B+W}{2} - S\right) k_p \qquad 0 \; min = B$$

$$u_L = 100 - \left(\frac{B+W}{2} - S\right) k_p \qquad max = W$$

Additional link: Line follower robot

How to be with two sensors?

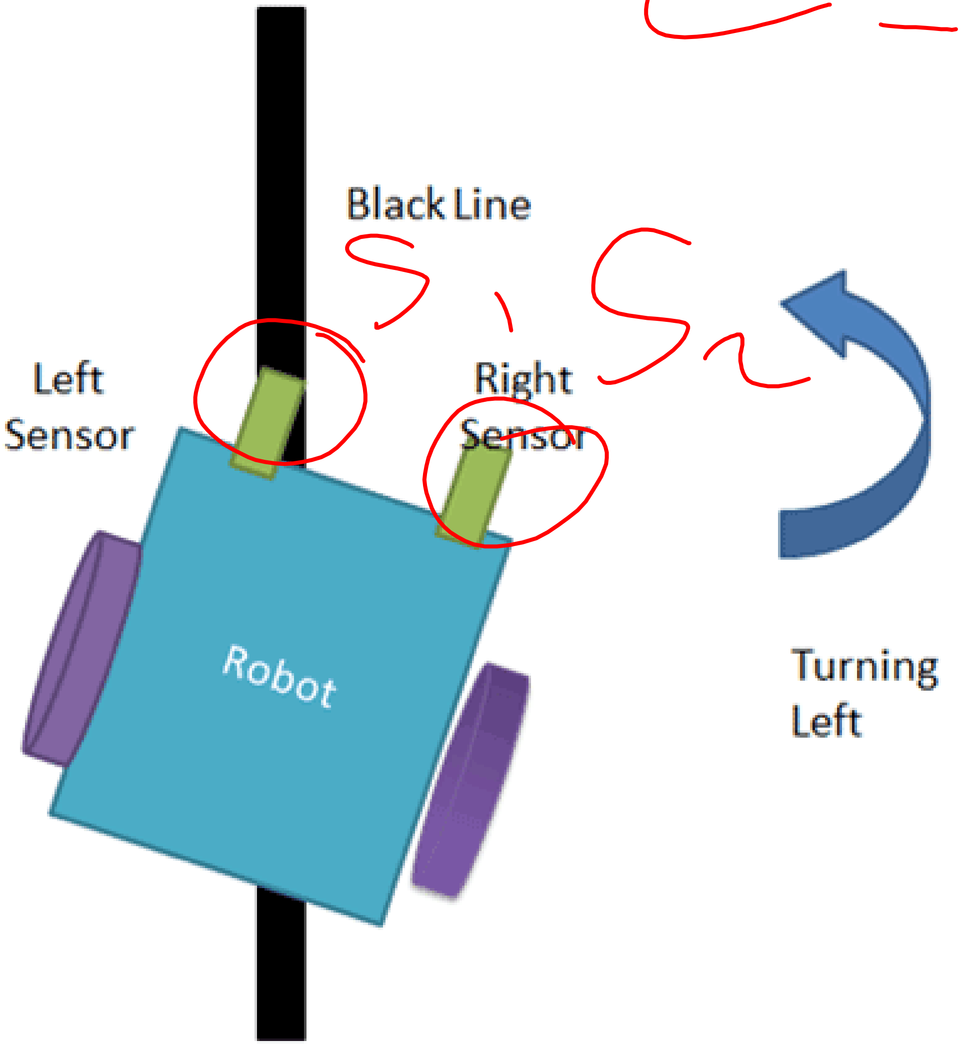
$$D = \frac{e_{k+1} - e_k}{T} \cdot k_D$$

$$e = S_1 - S_2$$

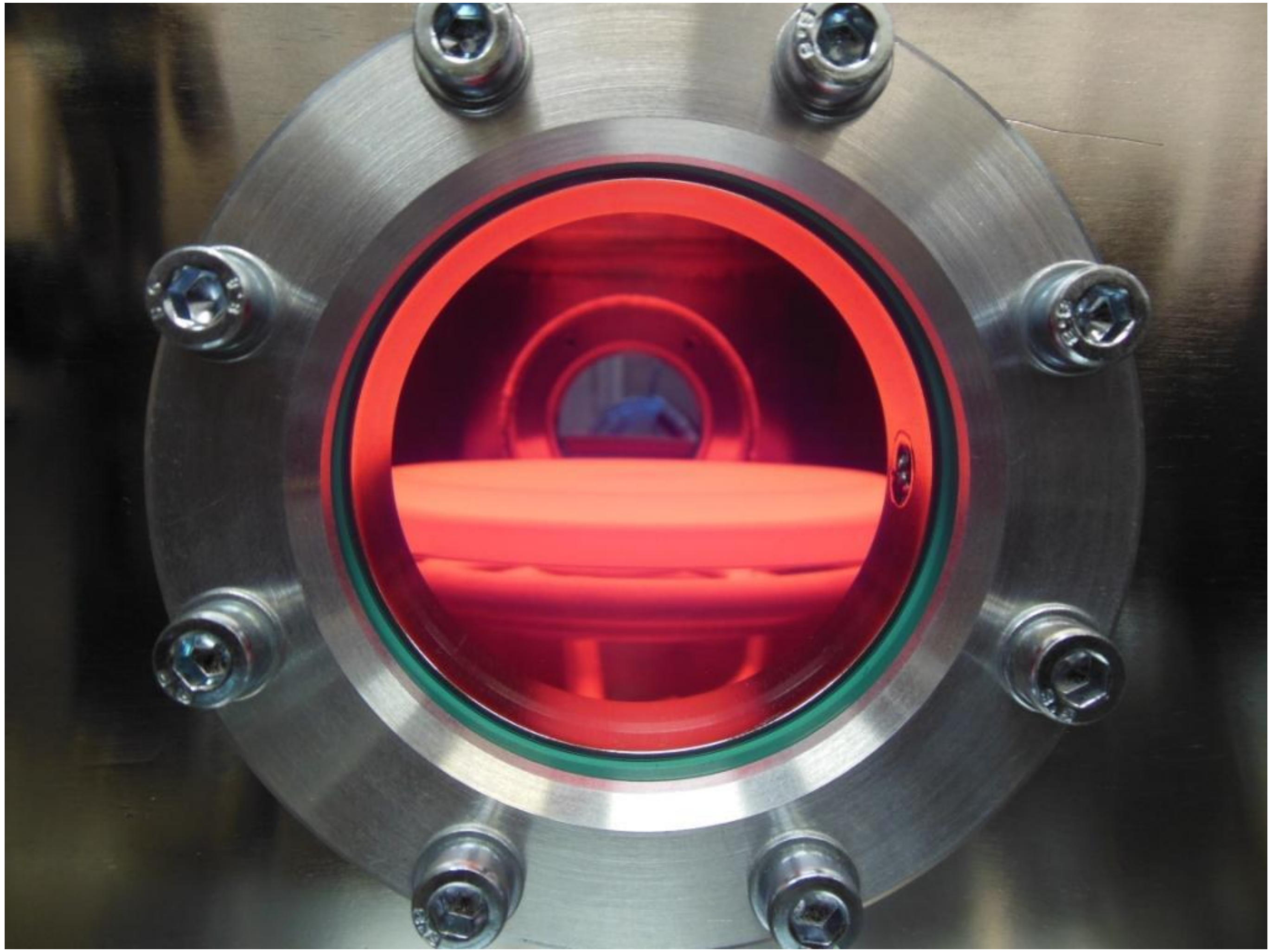
$$B = 25\%$$

$$W = 70\%$$

Left Sensor on black
Right sensor on white

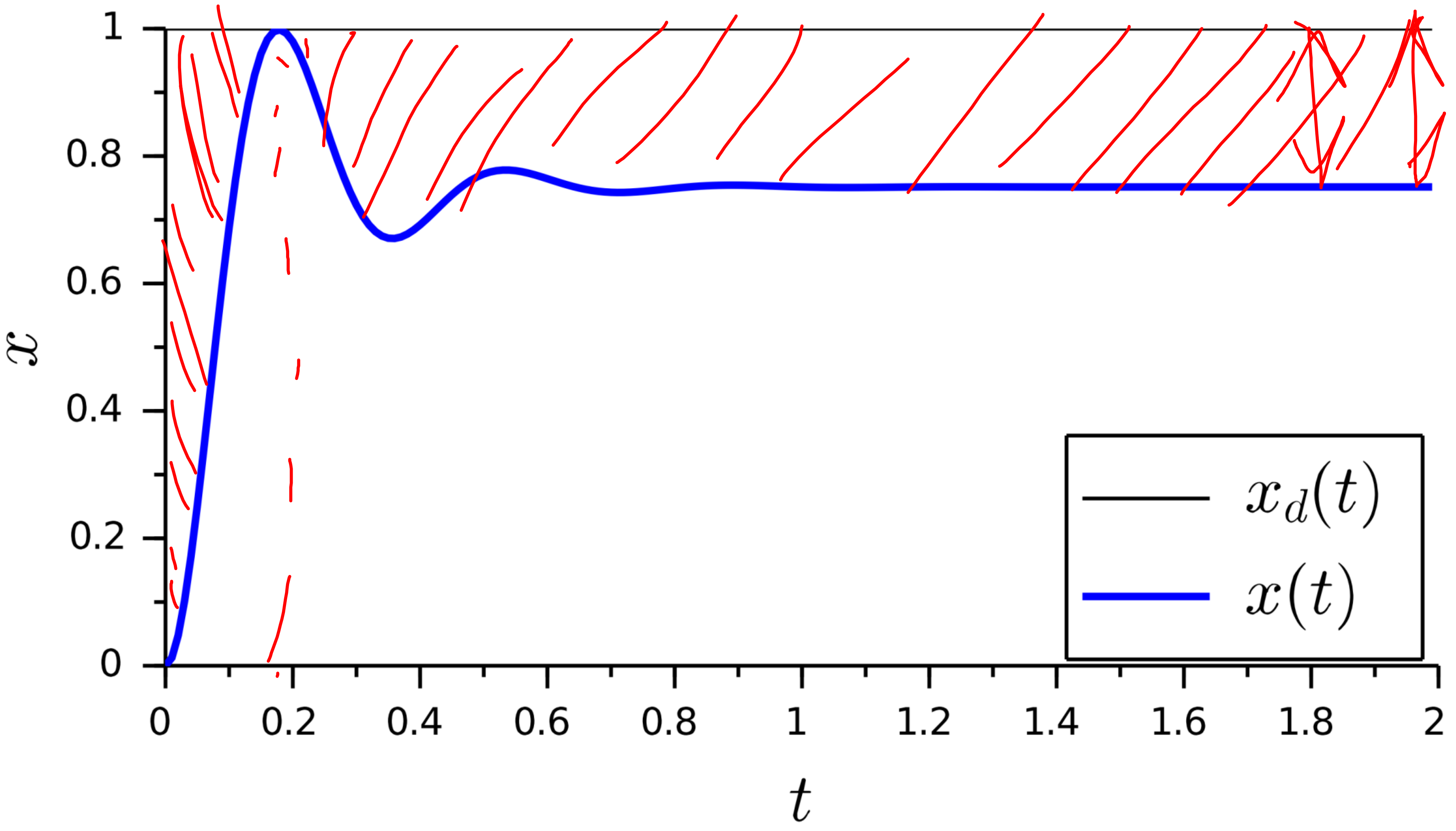


Where is PI-controller is enough?



Additional link: [PI Control of the Heat Exchanger]

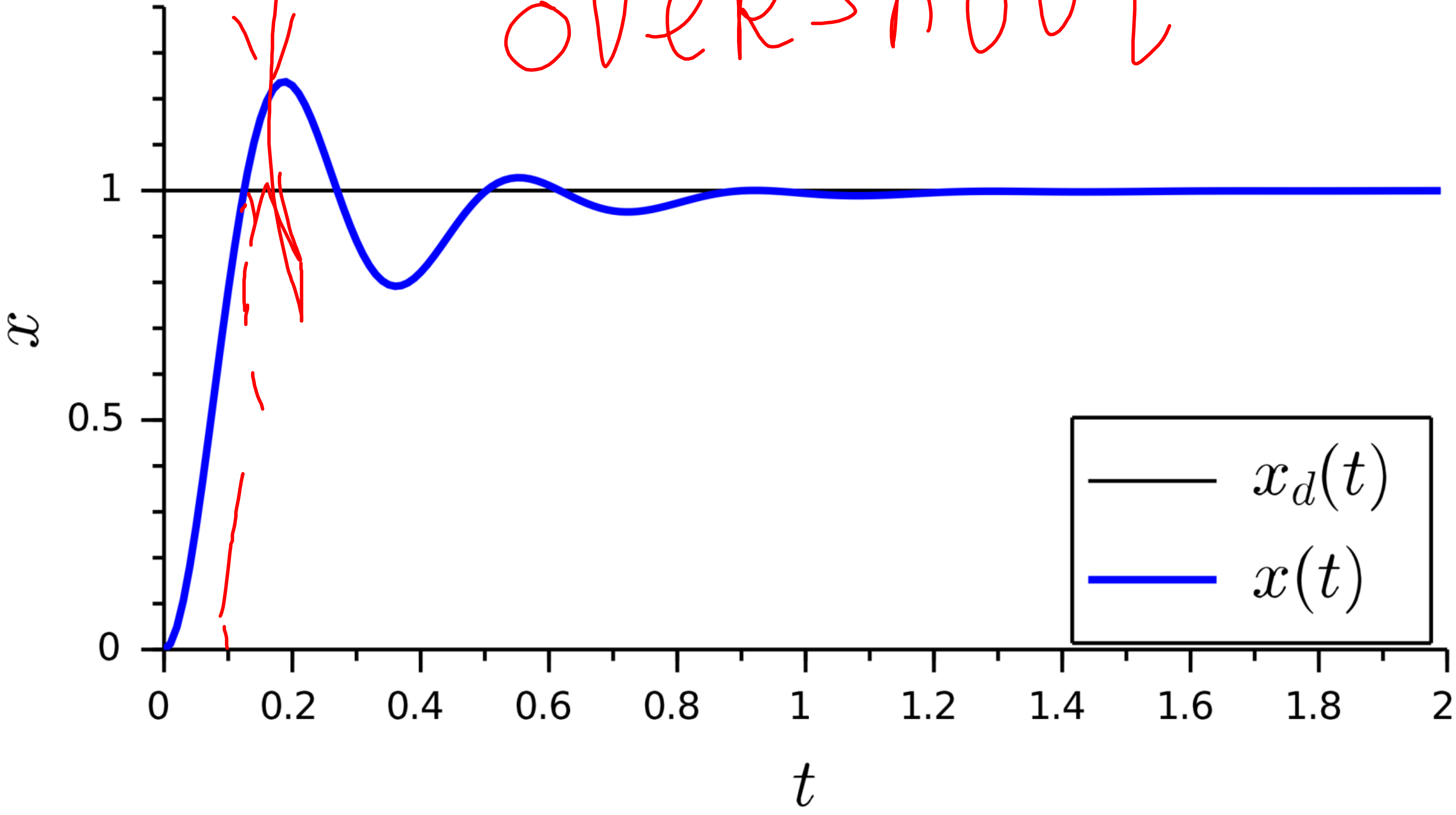
P-controller plot



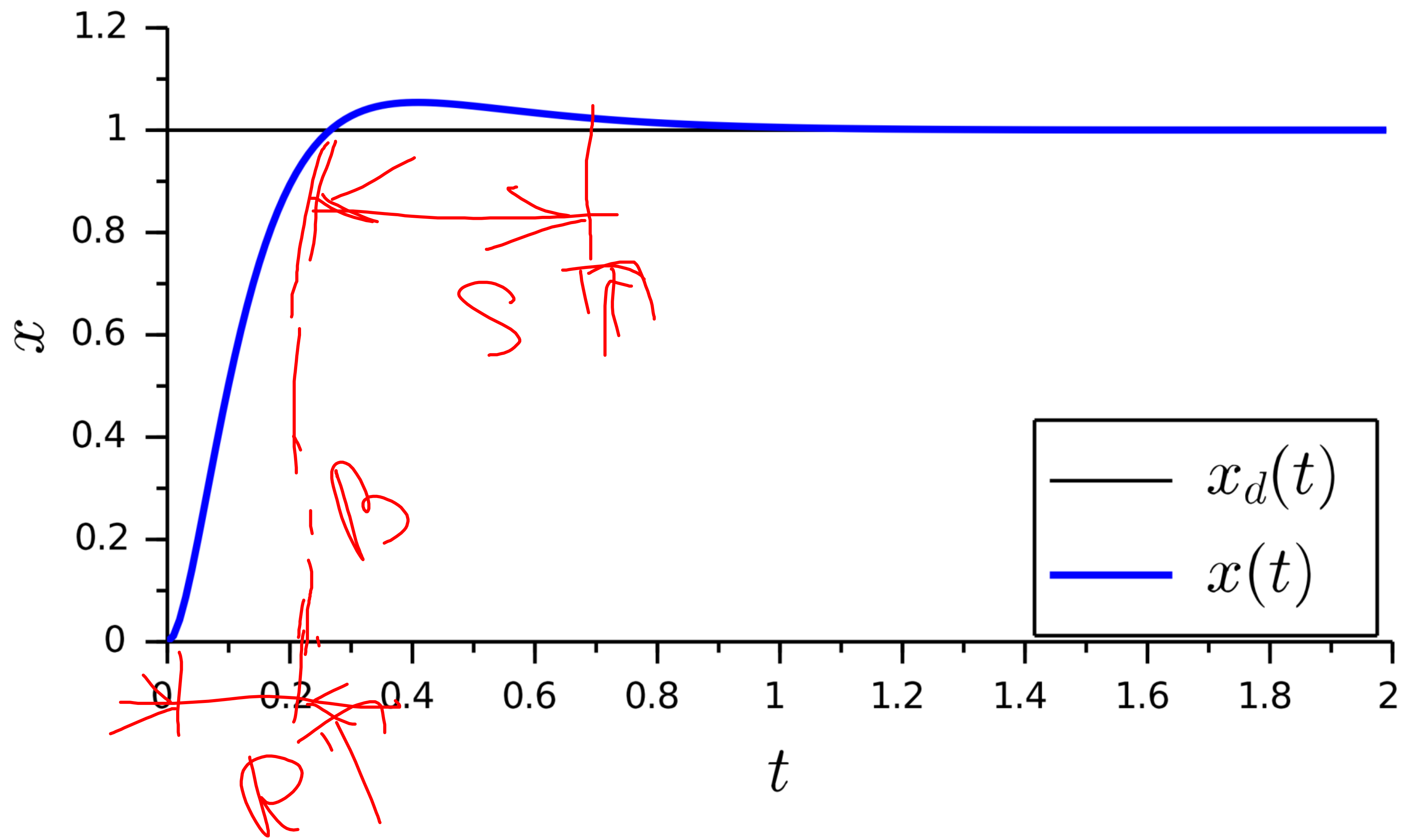
S-S ERROR

PI-controller plot

перерегулирование
overshoot



PID-controller plot



±5%

How do the PID parameters affect system?

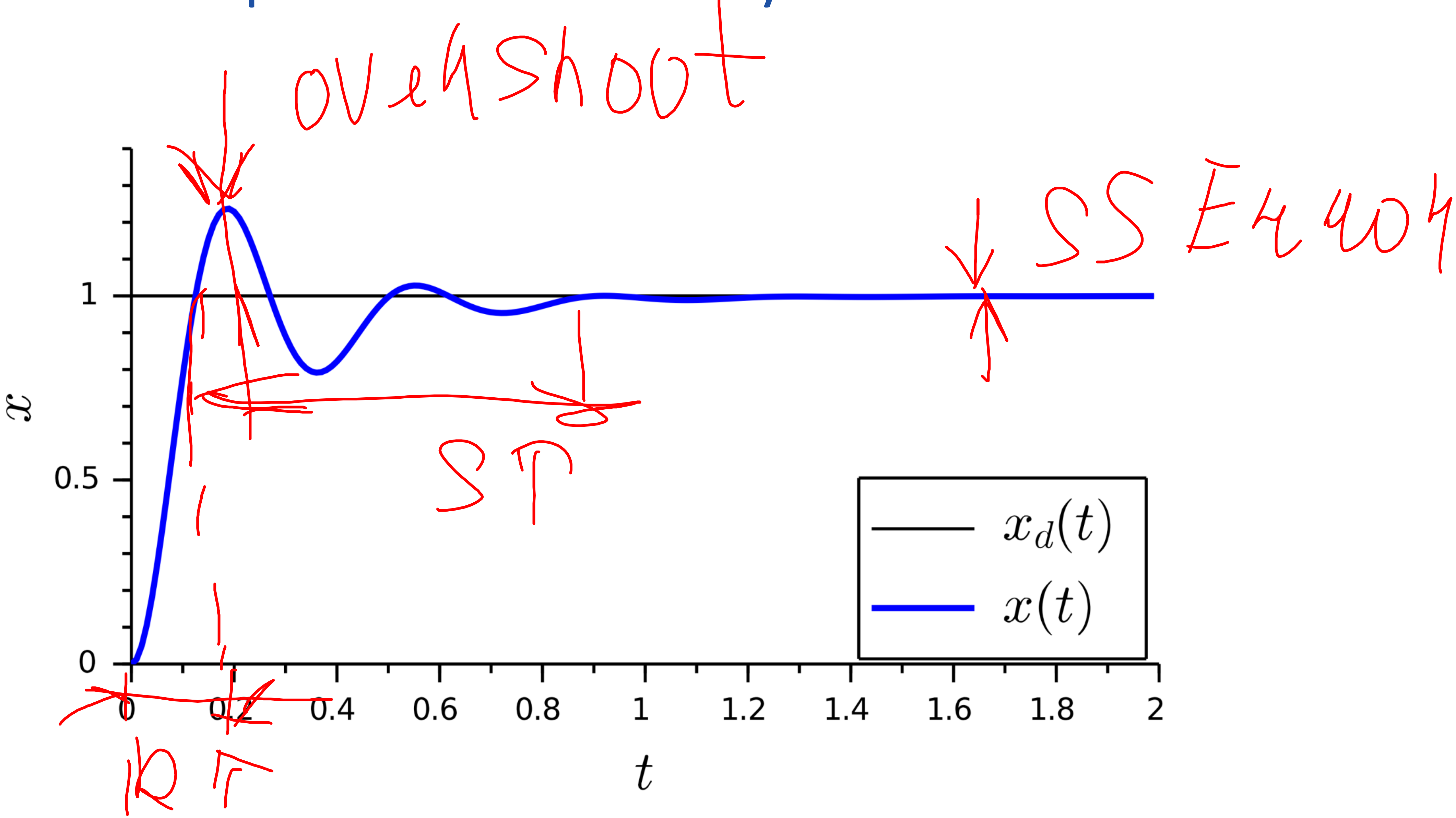
1. Rise Time: the time it takes for the plant output y to rise beyond 95% of the desired level for the first time.

2. Overshoot: how much the the peak level is higher than the steady state, normalized against the steady state.

3. Settling Time: the time it takes for the system to converge to its steady state.

4. Steady-state Error: the difference between the steadystate output and the desired output.

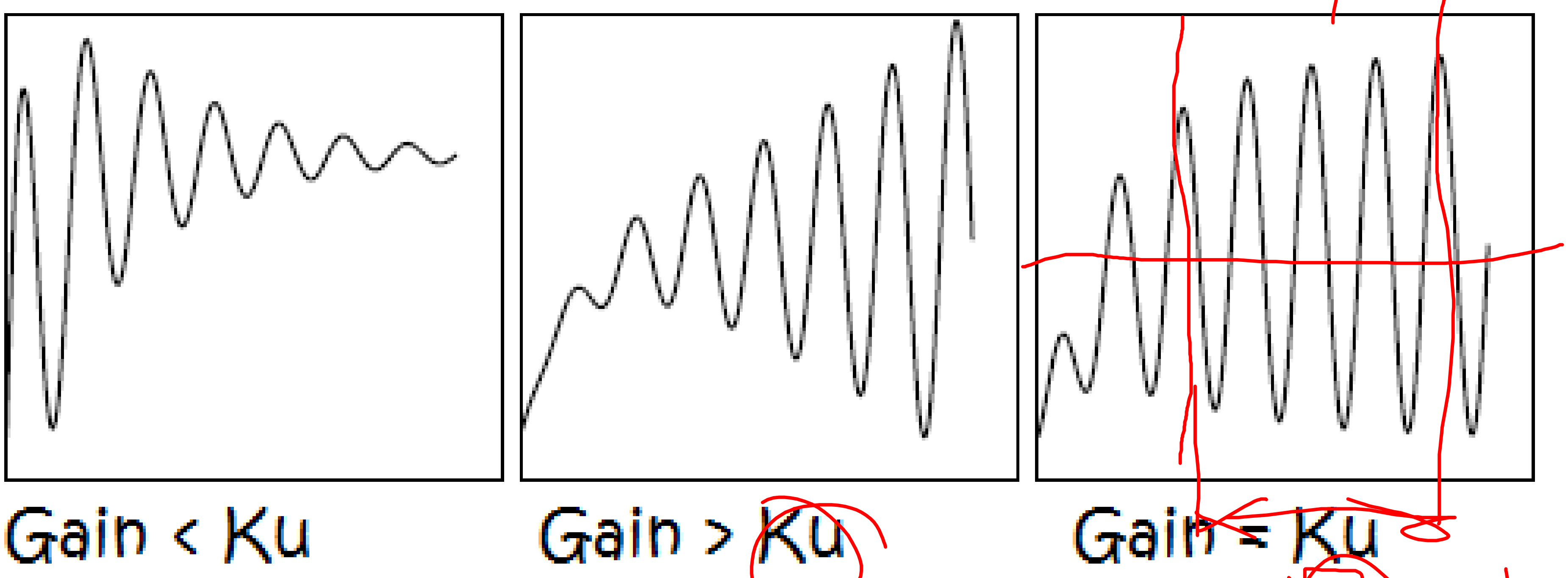
How do the PID parameters affect system?



PID-How do the PID parameters affect system?

Gains	Rise time	Overshoot	Settling time	S-S Error
Kp	Decrease	Increase	None	Decrease
Ki	Decrease	Increase	Increase	Eliminate
Kd	None	Decrease	Decrease	None

Ziegler-Nichols Ultimate Gain



Begin with a low/zero value of gain Kp

Increase until a steady-state oscillation occurs, note this gain as Ku

Check the period time of oscillations – it's Tu

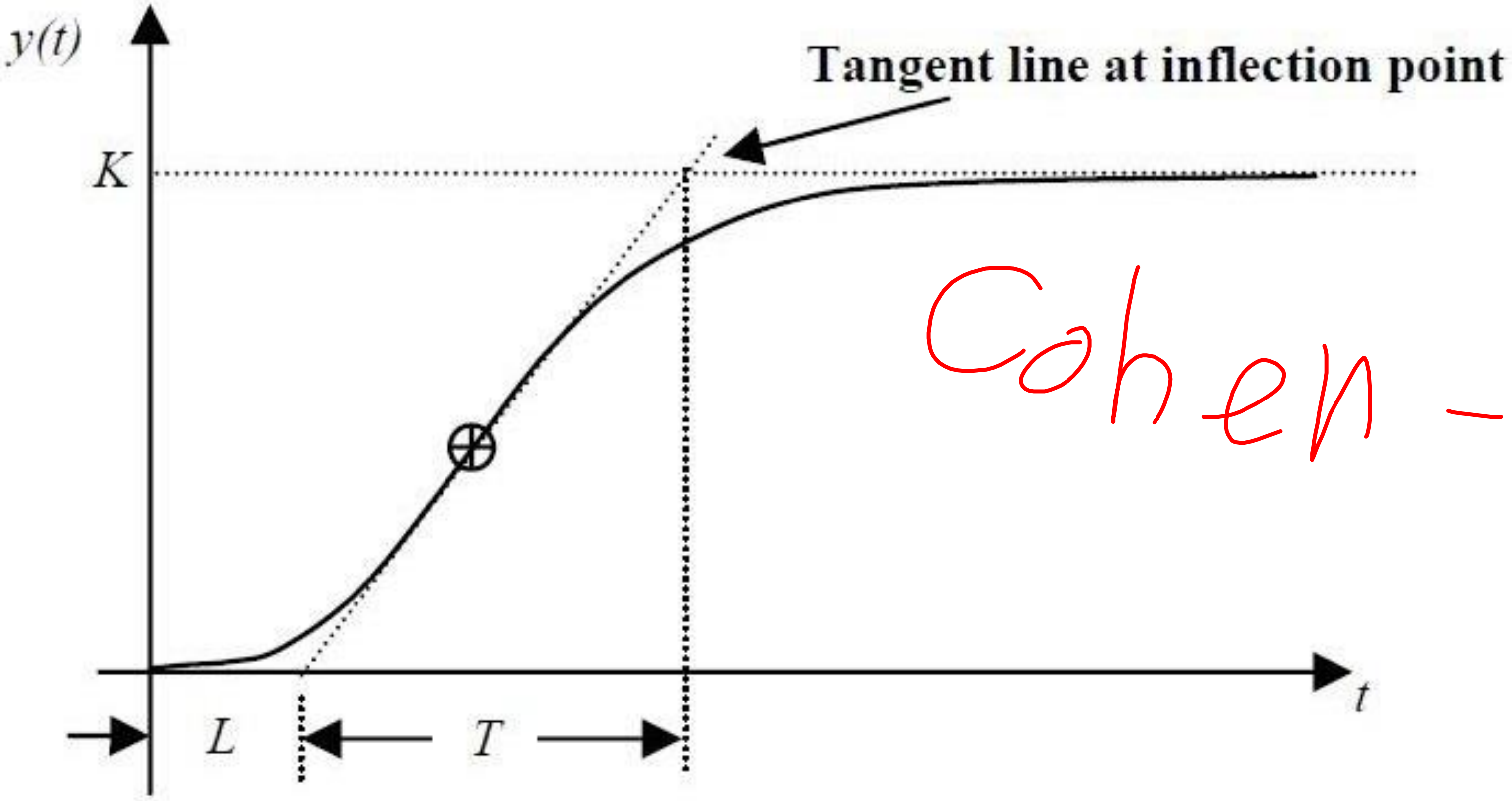
Ziegler-Nichols Ultimate Gain

Ziegler–Nichols method

Control Type	K_p	T_i	T_d	K_i	K_d
P	$0.5K_u$	–	–	–	–
PI	$0.45K_u$	$T_u/1.2$	–	$0.54K_u/T_u$	–
PD	$0.8K_u$	–	$T_u/8$	–	$K_uT_u/10$
classic PID	$0.6K_u$	$T_u/2$	$T_u/8$	$1.2K_u/T_u$	$3K_uT_u/40$
Pessen Integral Rule	$7K_u/10$	$2T_u/5$	$3T_u/20$	$1.75K_u/T_u$	$21K_uT_u/200$
some overshoot	$K_u/3$	$T_u/2$	$T_u/3$	$0.666K_u/T_u$	$K_uT_u/9$
no overshoot	$K_u/5$	$T_u/2$	$T_u/3$	$(2/5)K_u/T_u$	$K_uT_u/15$

Additional link: [Ziegler-Nichols for PID-controller tuning]

Ziegler-Nichols Step Response



Cohen-Coon TM

Response Curve for Ziegler-Nichols First Method

Ziegler-Nichols step response

PID Type	K_p	$T_i = K_p/K_i$	$T_d = K_d/K_p$
P	$\frac{T}{L}$	∞	0
PI	$0.9\frac{T}{L}$	$\frac{L}{0.3}$	0
PID	$1.2\frac{T}{L}$	$2L$	$0.5L$

Ziegler-Nichols Recipe – First Method

$$K_i = \frac{K_p}{T_i}; K_d = K_p T_d.$$

See you soon!