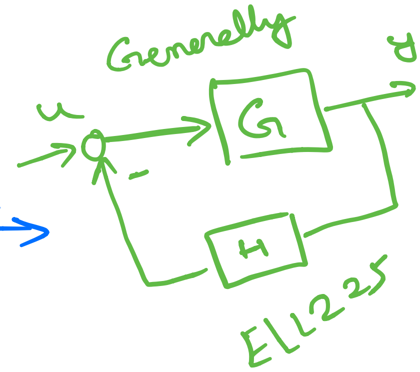
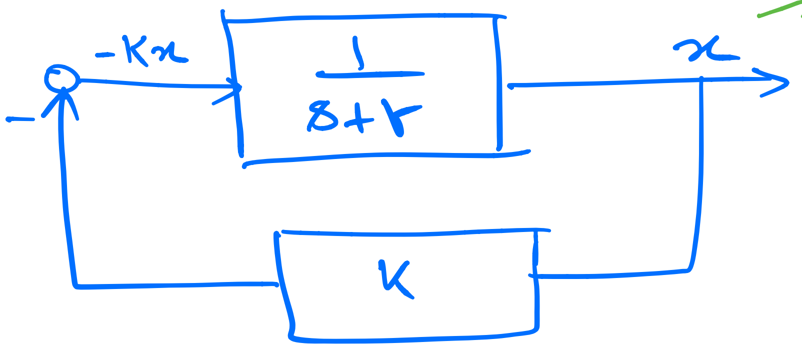
ELL707

27.01.2020



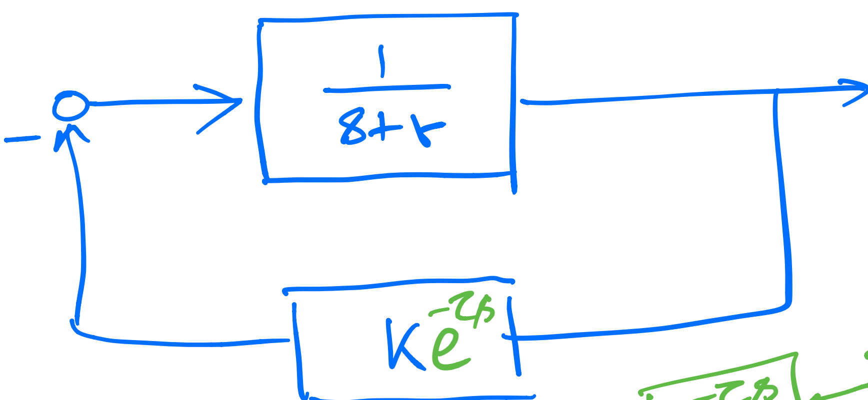


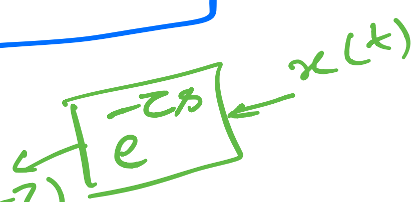
What is corresponding differential equation?

$$\left(\frac{d}{dt}+r\right)x = -Kx$$

$$\frac{dx}{dt}+rx=-Kx$$

Aim: Add <u>delay</u> to above negative feedback loop and analyze behaviour

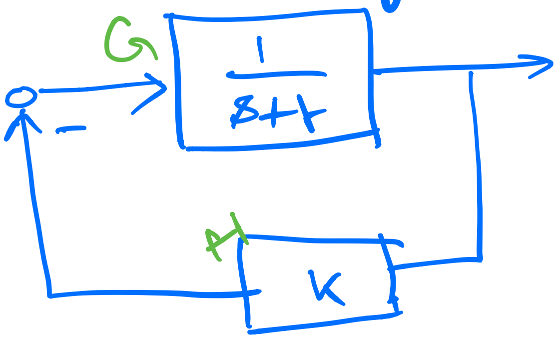




$y(t)=x(t-\tau)$

Linear or Nonlinear? Check using superposition.

No Delay



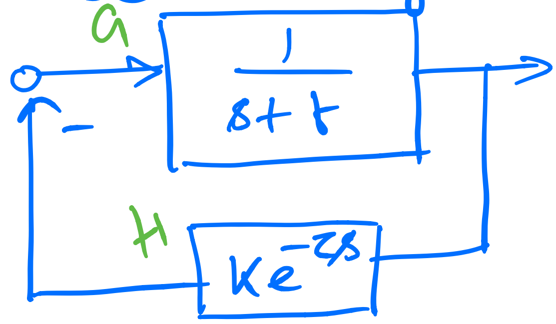
- Stable ?
- overall (Transfer function) block may be represented as

$$\frac{1}{s+r+K}, \quad K>0, \; r>0$$

- corresponding differential equation
$$\equiv \frac{dx}{dt} = -(r+K)x$$

- $\Rightarrow$ Stable as poles are in LHP (left half of complex plane)

Yes Delay



- Stable? (should be stable)
- $$\frac{1}{s+r+Ke^{-\tau s}}$$
- Check stability using Nyquist Plot
-

Nyquist Plots / Bode Plots

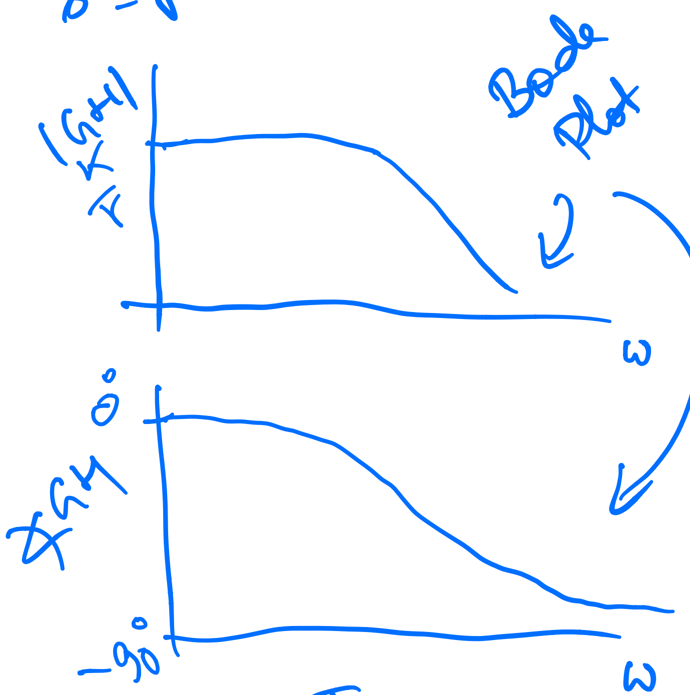
$$\frac{G}{1+GH}$$

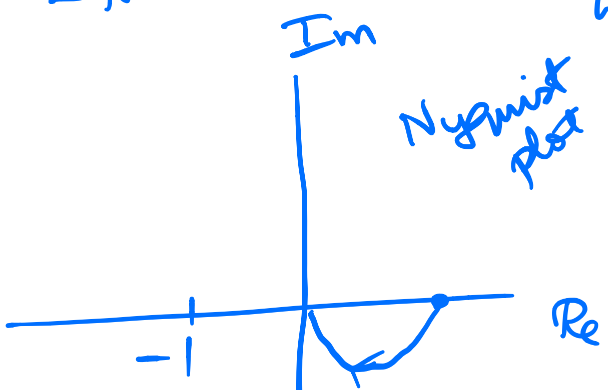
Want to check if $\underset{(s)}{G}\underset{(s)}{H} = -1$ and for what value of s this happens.

No delay,

$$GH = \frac{K}{s+r}$$

$s = j\omega$

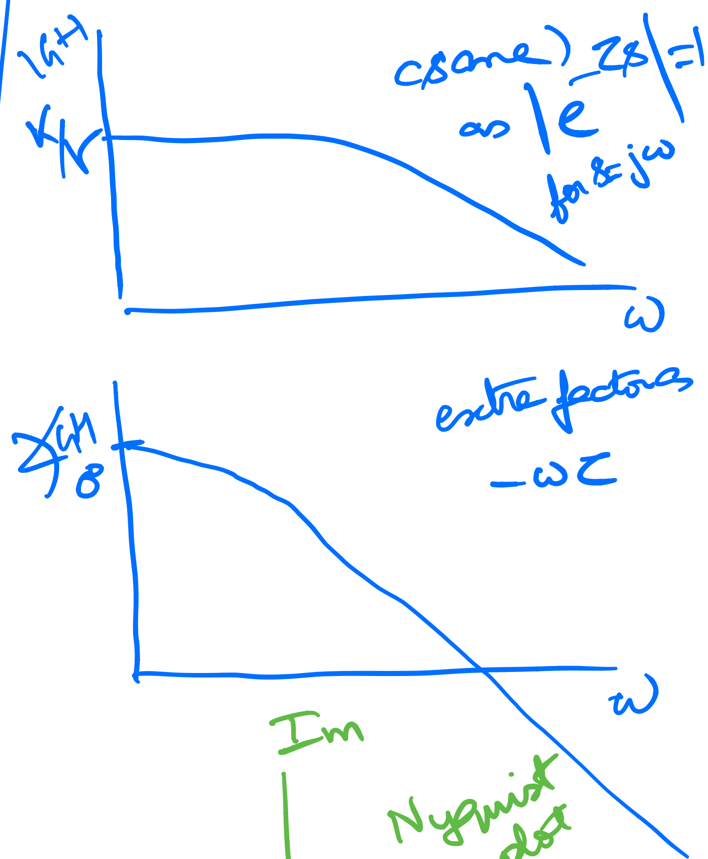


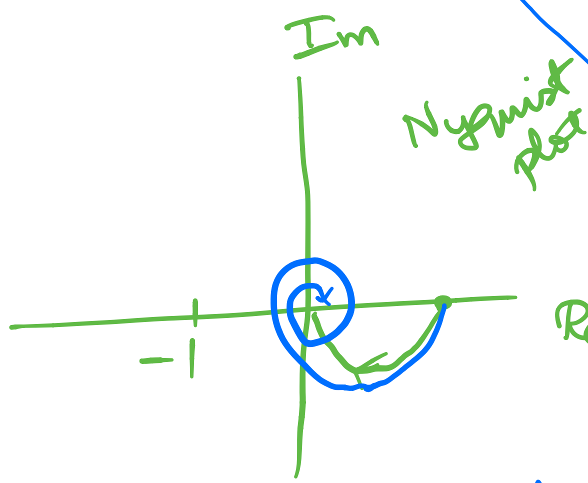


Never hits -1

Yes delay

$$GH = \frac{Ke^{-\tau s}}{s+r}$$





Could hit -1 for some values of K, τ, r.

- large τ, K may allow curve to hit '-1'
- may become unstable.

I want to say: These points of instability are those that correspond to purely imaginary roots of $s + r + \kappa e^{-\tau s} = 0$

$$\frac{d^2x}{dt^2} + \omega^2 x = 0 \quad \equiv \quad \longrightarrow \boxed{\frac{1}{s^2+\omega^2}} \longrightarrow$$

$$(s^2 + \omega^2)\, X(s) = (\ )\, x(0) + (\ )\, \dot{x}(0)$$