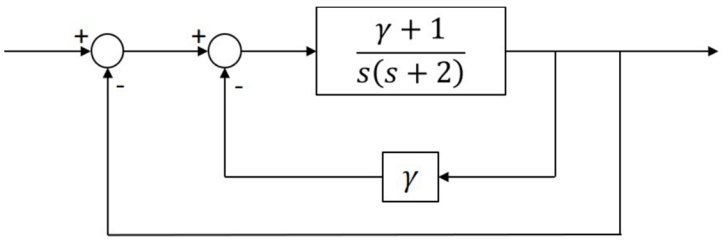
## Controls – 1

1. Consider the system $G(s) = \frac{1}{(\tau_1 S+1)(\tau_2 S+1)}$ and consider the feedback loop obtained using the controller $C(s) = \frac{K}{s}$. Obtain the stability range for $K$using:
   a. **(5 Points)** Routh Hurwitz Criterion.
   b. **(15 Points)** Root Locus (remember that $\tan(\alpha+\beta) = \frac{\tan(\alpha)+\tan(\beta)}{1-\tan(\alpha)\tan(\beta)}$)
   c. **(20 Points)** Nyquist stability criterion (remember that gain margin GM = $\frac{1}{G_o(j\omega_c)}$ where $\omega_c$ is the frequency where the phase of the OL transfer function is equal to $180^0$.)

2. **(20 Points)** The Block diagram of a closed loop system is provided in the figure below. Construct the root locus for $\gamma \geq 0$.




3. Consider the following dynamic system model for control of the y-axis motion

$$M\ddot{y}(t) + K_s y(t) = u(t),$$

where $K_s$= 0.5 Nm/m, $M$= 500 kg, and $u(t)$ is the control input given by

$$u(t) = -K_p y(t) - K_d \dot{y}(t).$$

   a. **(10 Points)** Draw a functional block diagram for the system.
   b. **(10 Points)** Find the characteristic equation of the closed-loop system.
   c. **(20 Points)** Find the region in the $K_d$ versus $K_p$ plane in which the system is stable.