## 2nd Assignment:
## **Single-input single-output (SISO) systems**

1. Which methods are available in robust control theory for modeling uncertainty?

2. What is an uncertainty weighting function $W(s)$? How does it look like and how can it be determined?

3. What is a performance weighting function $W_{\mathrm{P}}(s)$? How does it look like?

4. Consider the plant transfer function
$$G(s) = \frac{2}{5s+1} e^{-Ts}.$$
where the delay $0 \le T \le 2.5\,\mathrm{sec}$. For controller design, it is simplest and sometimes best to use a delay-free nominal model of the plant and to represent the nominal delay as additional uncertainty. Therefore, the nominal plant transfer function is chosen as
$$G_0(s) = \frac{2}{5s+1}.$$
Derive a multiplicative dynamic uncertainty model of the given plant!

5. A robot has been designed to aid in hip-replacement surgery. The device, called RoBoDoc, is used to precisely orient and mill the femoral cavity for acceptance of the prosthetic hip implant. Clearly, we want a very robust surgical tool control, because there is no opportunity to re-drill a bone. The control system follows the standard feedback control with the plant transfer function given by
$$G(s) = \frac{b}{s^2 + as + b}$$
where $1 \le a \le 2$ and $4 \le b \le 12$. The system is controlled by the following controller
$$K(s) = 52.96\frac{s^2 + 1.5s + 8}{s(s^2 + 20s + 101)}.$$
   - Derive an uncertainty model for the given system!
   - Check if the given controller satisfies the common rules of thumb for phase and gain margins!
   - Investigate the nominal and robust stability of the closed-loop system!
   - Does the given controller guarantee a closed-loop bandwidth $\omega_{\mathrm{B}} = 1$ rad/sec, a sensitivity function with $M_{\mathrm{S}} = \sqrt{2}$ and a slope $-1$ below the bandwidth?

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