Experiment 3

Controller design on MATLAB platform by analog frequency response.

Background:

Check out the advantages of *bandwidth* based **frequency domain designs**, as covered in your lecture course !

A problem of medical origin is presented below, where you need to decide external control for patients with respiratory issues.

Objective:

The project requires design of a cascade *ventilator transfer function* for a given analog *respiratory system* transfer function, according to desired specifications provided.

Tutorial:

In the MATLAB platform, go through the procedural steps as described for:

- *Frequency-Domain Characteristics on Response Plots:*
  https://www.mathworks.com/help/control/ug/system-characteristics-on-response-plots.html

- *Frequency response of a SISO system:*
  https://www.mathworks.com/help/control/ug/frequency-response-of-a-siso-system.html

- *Frequency response of a MIMO system:*
  https://www.mathworks.com/help/control/ug/frequency-response-of-a-mimo-system.html

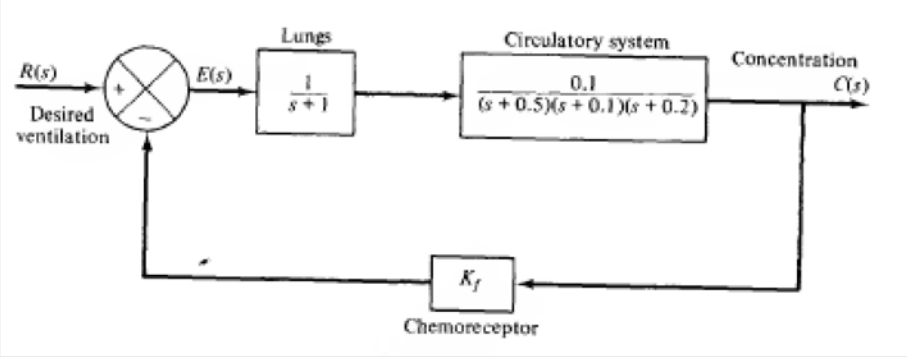
Elements of the software for familiarisation:

i. ***Functions/keywords:*** bode; bodeoptions; bodeplot; freqresp; sigma; sigmaplot; tf; zpk.

ii. ***Tools:*** Plot customization:
https://www.mathworks.com/help/control/analysis-plot-customization.html

Project:

A respiratory ventilator is to be designed as a cascade controller to the **human respiratory system**. The OLTF of this system has the analog first order transfer function of the ***lungs***, cascaded to the third order transfer function of ***blood circulation***, the output of which is the *carbon-dioxide concentration* in blood vessels. ***Chemoreceptors*** in the human brain sense the carbon-dioxide concentration and provide a feedback to the brain to *motor control* ventilation to the lungs. The ***chemoreceptors*** serve as a simple gain block (K_f = 0.1 nominally) for the sensing action in the feedback path.



- For the typical value of chemoreceptor gain provided, obtain the gain and phase margin of the system.
- An endocrinal problem in the patient may lead to flawed chemoreceptors that may change the nominal feedback gain *up to ten times in the worst case !*
- An asthmatic patient may, on the other hand, have the time constant of *lungs* increased by *up to a factor of ten in the worst case !*

In all cases, the ventilator should maintain a phase margin of 45^o for the system CLTF.

For observations and discussions:

Design the cascaded ventilator transfer function (placed in the forward path before the lungs, of course !) that will take care of the above medical requirements.

Note that while the ventilator transfer function must be “as simple as possible”, you are not provided any leads ! That is, you need to begin by choosing the number of poles and zeros, and may even have to change your choice down the line.

Record and discuss the various aspects that affect the design, and how you handle them through frequency response studies.