# Studio #7: Assessing Stability Using Routh-Hurwitz Method

The objective of this studio is to reinforce recently learnt concepts in the class on stability and Routh-Hurwitz method.

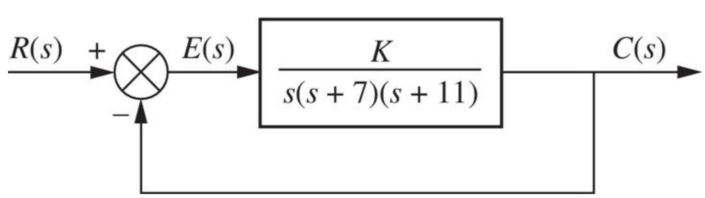
1. (Example 6.2, Nise) Determine the stability of the closed-loop transfer function below:

$$T(s) = \frac{10}{s^5 + 2s^4 + 3s^3 + 6s^2 + 5s + 3}$$

There are several methods to ascertain stability of the aforementioned system. For example, one can use Matlab commands such as `pole()`, `roots()`. Alternatively, one can use methods such as root locus (to be covered later in the course), Routh-Hurwitz criterion, etc. The Studio Instructor will

a) Construct the Routh table for the closed-loop transfer function above and study the stability of the closed-loop system.
b) Use the Matlab commands `pole()` and `roots()` to verify the answer obtained in (a).
c) It is also possible to obtain the various cells of the Routh array using symbolic computation in Matlab. The Studio Instructor will now demonstrate to the students the Matlab file *`ch6sp1.m`*, and its applicability in obtaining the array. Please note that this file can also be found in the Studio 7 Assignment page on Canvas.

2. (Example 6.9, Nise) It is also possible to utilize the Routh array to design parameters or controller gains in the system, from the stability perspective. In the system shown in the Figure below, the Studio Instructor will first obtain a range of the gain K that will lead to a closed-loop system that is stable, unstable, or marginally stable. (Which transfer function should be used for obtaining the range?)




It is also possible to obtain this range using Matlab. The Studio Instructor will now demonstrate this by going through the Matlab script given in the file `ch6p2.m`, which can be obtained from the Studio 7 Assignment page on Canvas.

# Exercises

**Each student shall complete the exercise below and get their work checked off by the studio instructor.**

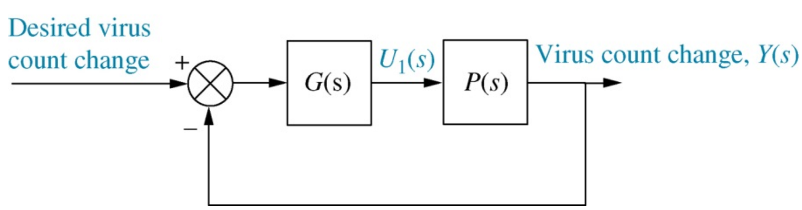
**For remote students and students who do not finish within the studio session:**

Compile your answers and outputs of Exercises 1 along with the Matlab code you used to answer the questions in a word file and name it LastNameFirstNameStudio7.docx. Your file shall include the solution to parts (a) through (e). Upload your file to Canvas under Studio 7.

1. Control of HIV/AIDS: The linearized HIV infection model has the following transfer function:

$$P(s) = \frac{Y(s)}{U_1(s)} = \frac{-520s - 10.3844}{s^3 + 2.6817s^2 + 0.11s + 0.0126}$$

It is desired to develop a policy for drug delivery to maintain the virus count at prescribed levels. For the purpose of obtaining an appropriate $u_1(t)$, a feedback will be used as shown below:




As a first approach, consider G(s)=K, where K is a constant to be selected.

(a) Use the Routh-Hurwitz criterion to find the range of K for which the closed-loop system is stable.
(b) Following the Matlab file `ch6p2.m`, write a Matlab code to obtain this range using Matlab.
(c) Select a value of K for which the system is marginally stable and plot the unit step response for t=0 till t=1000s.
(d) Select a value of K for which the system is stable and plot the unit step response for t=0 till t=1000s.
(e) Select a value of K for which the system is unstable and plot the unit step response for t=0 till t=10s.