LAB SESSION 5

Stability Analysis of Control System

Objective:

In this lab session we will explore the stability of the higher order systems without solving for the closed loop systems poles. The effect of the gain on a general system stability and find the values of the parameters used in the controller and the gain of a tracked vehicle turning control for which the system is stable.

Equipment Required:

PC and MATLAB® R2017b

Procedure:

the Routh-Hurwitz criterion is a necessary and enough criterion for stability. Given a characteristic equation with fixed coefficients, we can use Routh-Hurwitz to determine the number of roots in the right half plane. Whenever the characteristic equation is a function of single parameter, the Routh-Hurwitz method can be utilized to determine the range of values that the parameter may take while maintaining stability.

Let suppose we have a unity feedback system

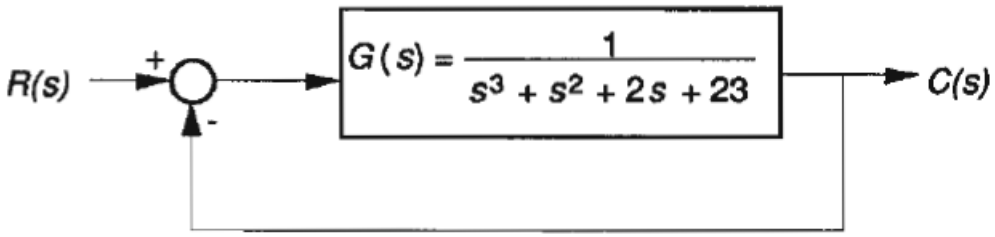
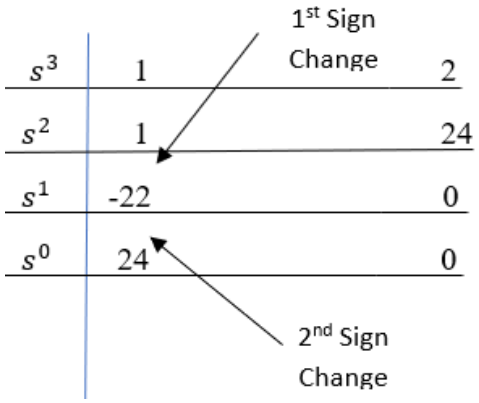


Figure 4.1 A Unity Feedback System

The characteristic equation is given by

$$s^3 + s^2 + 2s + 24 = 0$$

And the Ruth Hurwitz Table will be looks like



The number of sign changes in the above table represents the number of poles in the right half plane, as we can extract the result that there are total three poles and two are in right half plane and one in the left half plane. The Ruth-Hurwitz table can only depict a system is stable or not, the exact location of the system poles is unknown.

EXERCISE 1:

Draw the Ruth-Hurwitz table for the following transfer function

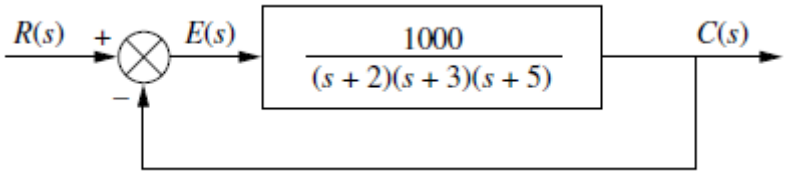


Figure 4.2 A Unity Feedback System

EXERCISE 2:

Explore the MATLAB command "**cloop**" to find the roots of the transfer function in exercise#1 and comment on the system stability.

Next, we will explore the range of the gain associated with our system. We will see how the change in the gain will compel our poles to move from the left half plane to the right plane and our system will become unstable.

Consider a unity feedback system with a gain K

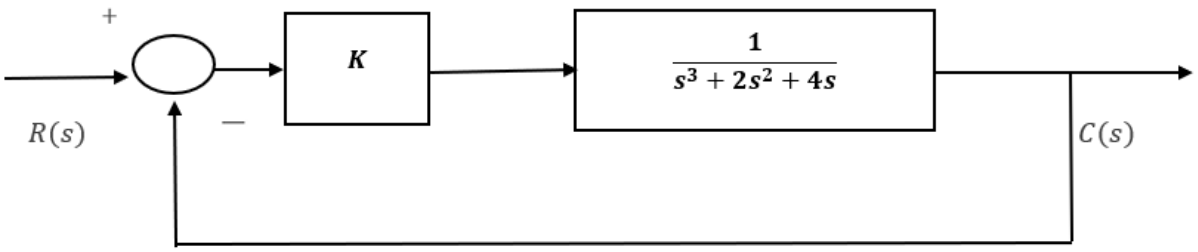


Figure 4.3 A Unity Feedback System with gain K

EXERCISE 3:

Find the characteristic equation of the above system as a function of "**K**", draw the Ruth-Hurwitz Table and write a MATLAB code in which you change the value of "**K**" from 0 to 8 and plot the movement of poles.

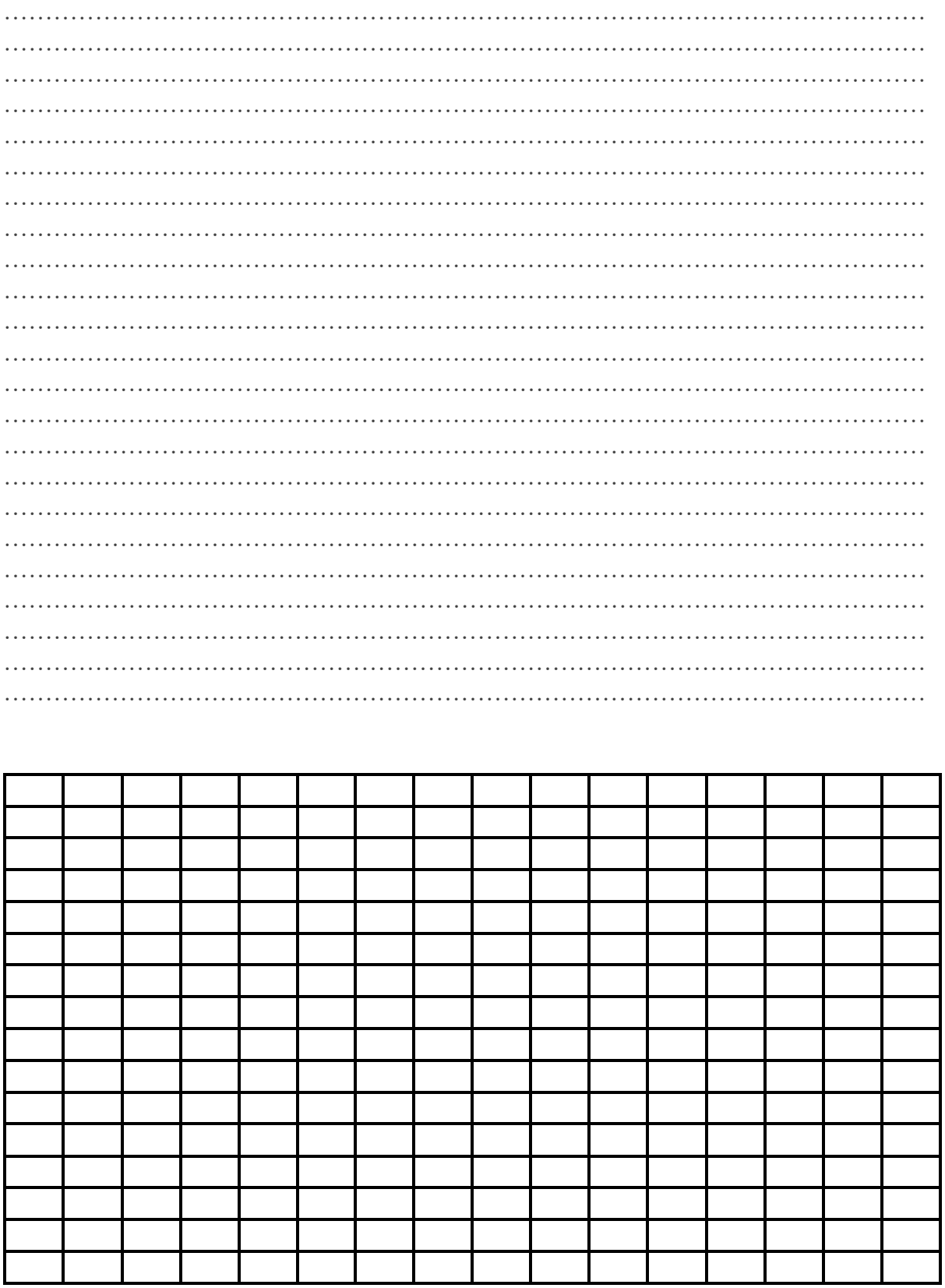


Figure 4.4 Movement of poles by varying the values of K

Now we will analyze a practical example of a tracked vehicle turning control, the block diagram of the feed back is shown in the fig. the design objective is to find the values of K and a such that the system is stable.

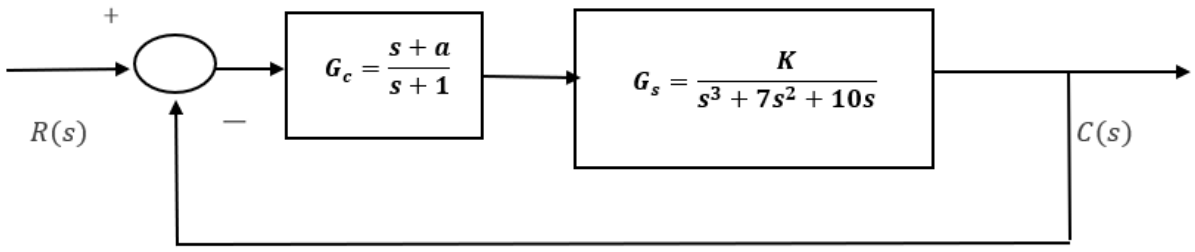


Figure 4.5 Tracked Vehicle turning control system

EXERCISE 4:

Find the characteristic equation for the system in fig 4.5 and draw the Ruth-Hurwitz table and estimate the values of $\boldsymbol{K}$ and $\boldsymbol{a}$.

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EXERCISE 5:

Write a MATLAB program for the system given in the fig 4.5 which shows the two regions, stable and unstable and plot the output.

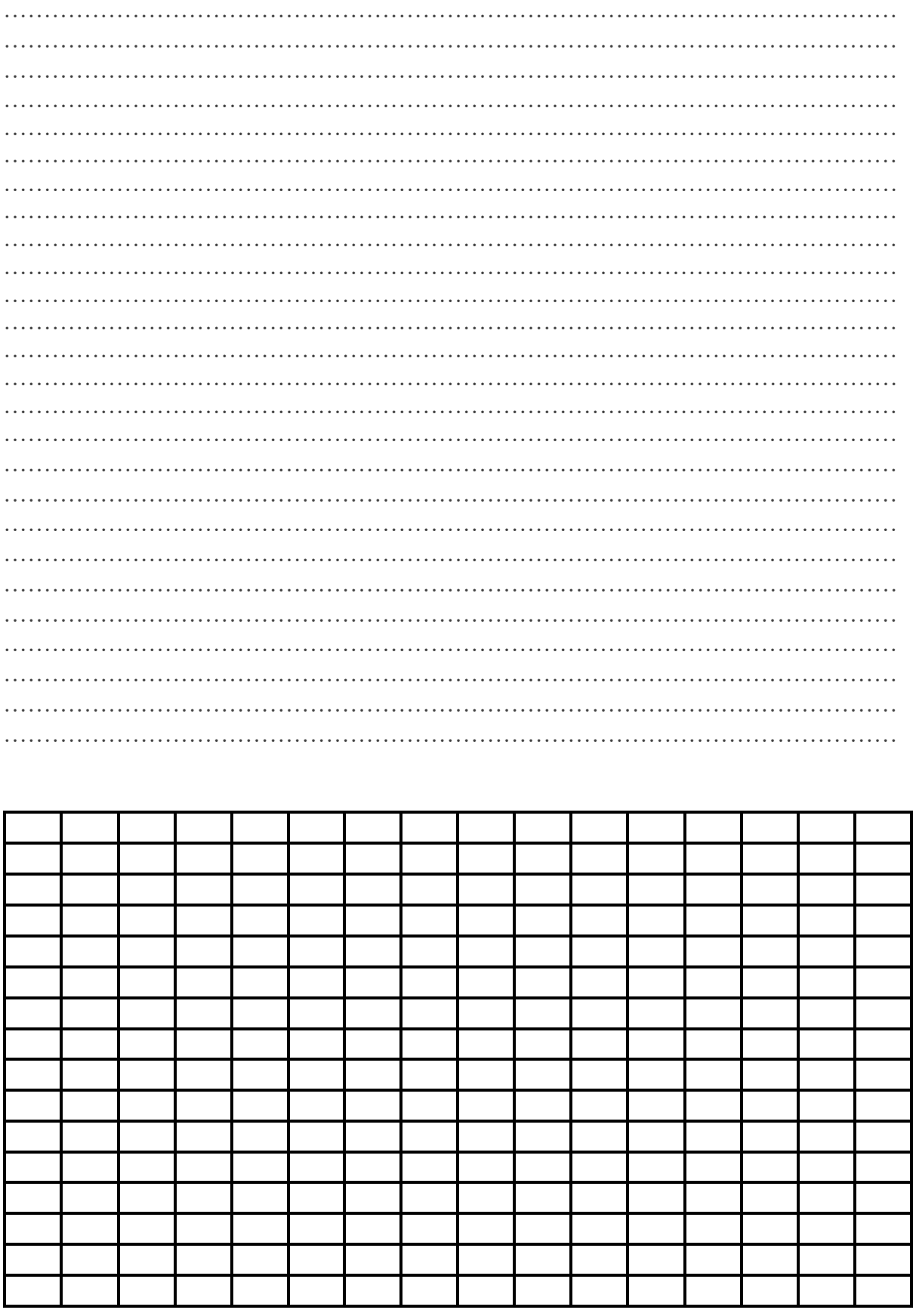

Figure 4.6 Stable and Unstable region for the feedback system