EE 302 - HW3 **Due Date: April 22, 2018 Time: 23:55**

Q1. Using the Routh-Hurwitz criterion, determine the stability of the closed-loop systems having the following characteristic polynomials. In each case, also determine how many poles are unstable or critically stable (on the jw-axis).

a. $q(s) = s^3 + 20s^2 + 10s + 400$
b. $q(s) = s^5 + 3s^4 + 2s^3 + 6s^2 + 3s + 1$
c. $q(s) = s^4 - s^3 + 2s^2 - 4s - 8$
d. $q(s) = s^5 + 2s^4 + 16s^3 + 32s^2 + 100s + 200$

Q2. The open-loop transfer function of a unity negative feedback control system is given by

$$G(s)H(s) = \frac{K(s+2)}{s(1+Ts)(1+2s)}$$

The two system parameters K and T may be represented in a plane where K is the horizontal axis and T is the vertical axis. In this T-versus-K plane, determine the regions for which the closed-loop system is stable and unstable. Also show the boundary on which the system is critically-stable.

Q3. Consider the following open-loop transfer functions. Construct the root-locus plots for the unity-negative-feedback systems for parameter indicated parameter range. Determine all necessary details.

a. $G(s) = \frac{K}{s(1+0.02s)(1+0.05s)}$, for $K > 0$.
b. $G(s) = \frac{K}{s(s+1)(s+2)(s+5)}$, for $K > 0$.
c. $G(s) = \frac{10(s+\alpha)(s+3)}{s(s^2-1)}$, for $\alpha > 0$.

Q4. **a.** Use the Matlab's root finding function `roots(.)` to determine the roots of the characteristic equations from Q1. Compare the results with your Routh-Hurwitz findings.

b. Use Matlab's `rlocus(.)` command to sketch the root-locus plots from Q4. Verify the sketches you obtained analytically. (Hint: You may need to manipulate (c.) into the suitable form before being able to use the rlocus tool.)

c. Consider the system in Q4.a. Use rlocus(.) tool to find the proper system gain to obtain an dominant 2nd order underdamped system that would exhibit approximately 15% overshoot. (Hint: Use `rlocus(sys, K)` with a suitably long user generated K vector and explore the plot with your mouse.) Plot the resulting closed-loop system response using the `step(.)` command.