Q1. Consider the feedback control system given in the figure below:

(a) Put the system into the standard form 

\[ q(s) = 1 + G(s)H(s) = 1 + K \frac{Z(s)}{P(s)} \]

where \( Z(s) \) is composed of open-loop zeros and \( P(s) \) is composed of open-loop poles of the system.

(b) Sketch the root-locus of the system for positive values of \( K \). Also find the break-away and break in points.

(c) Can you find a condition on positive \( K \) values for which the system is unstable?

Q2. Consider the feedback system whose open loop transfer function is given by

\[ KG(s)H(s) = \frac{64K}{s(s+4)(s+16)} \]

(a) Sketch the root-locus of the system, explicitly determining all critical points on the sketch and indicating them on your sketch.

(b) Verify your root locus sketch using the Matlab’s \textit{rlocus(.)} command.

(c) From your root-locus sketch, what is the condition on a positive \( K \) value for a stable system?

(d) Suggest a \( K \) value for the system to have a “reasonably good” time response. Also comment on what you find “reasonable” for the system (justify your selection).

Q3. For the system given in Q2;

(a) Define the system in Matlab for a variable \( K \) and plot its unit step response for the \( K \) value you have selected in Q2.

(b) Experiment with a family of different stable \( K \) values by plotting the corresponding unit step responses on the same plot with different line styles.

(c) Use computer simulation (\textit{step(.)} command) to determine the required gain value for a maximum overshoot of \( M_p = 10\% \). What is the corresponding rise time \( t_r \)?

(d) What would be the new rise time if we allow the maximum overshoot of 20\%?

(Note: You may also use Simulink to construct this system and simulate its behavior.)

Q4: Sketch the root-locus of the feedback system whose open-loop transfer function is

\[ KG(s)H(s) = \frac{K}{s(s+3)(s^2 + 6s + 64)} \]

Try to find and indicate on your sketch, all critical points of the locus. (Note: Use the Routh-Hurwitz Method to find the presence of the \( jw \) axis crossing and the corresponding \( K \) value.) Find also the departure and arrival angles if any.