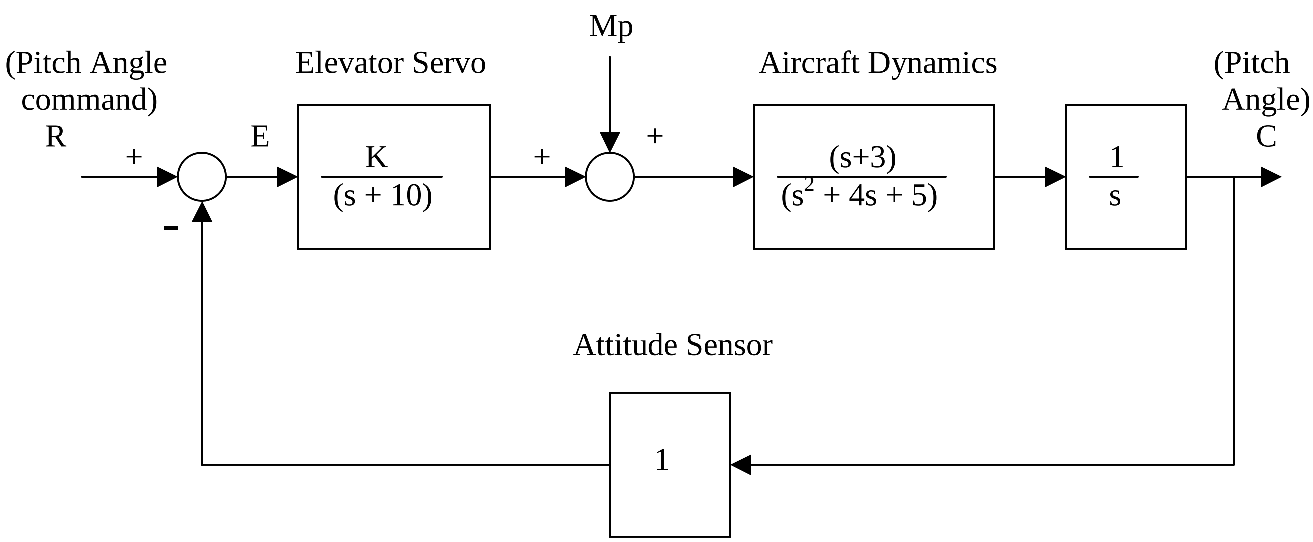
PROBLEM 8 (20%)

Uncle Steve's latest "get-rich-quick" scheme involves installing a free bar in the tail of commercial airplanes to lure customers. These aircraft experience a sudden shift in weight as the passengers rush the bar when it first opens. To compensate for the sudden shift, airlines participating in Uncle Steve's new service are required by the FAA to install a pitch-attitude autopilot that keeps the pitch (up-and-down position of the nose) relatively constant in the face of disturbances. Assume that the passenger movement results in a unit step disturbance at time $t = 0$ of $Mp(t) = u(t)$. An autopilot loop for your consideration is shown below:



A.) What value of K is required to keep the steady-state error E less that 0.1 radians (about 6 degrees)?

B.) Draw neat Root Locus diagrams on the answer sheet for positive and negative K that describe the closed loop pole locations.

C.) Draw a Nyquist plot for the system. Use a D-contour that encompasses the right-half s-plane and that contains gee-gaws that avoid including poles inside the D-contour.

D.) Using any method, determine the ranges of K (both positive and negative) that make the system stable.

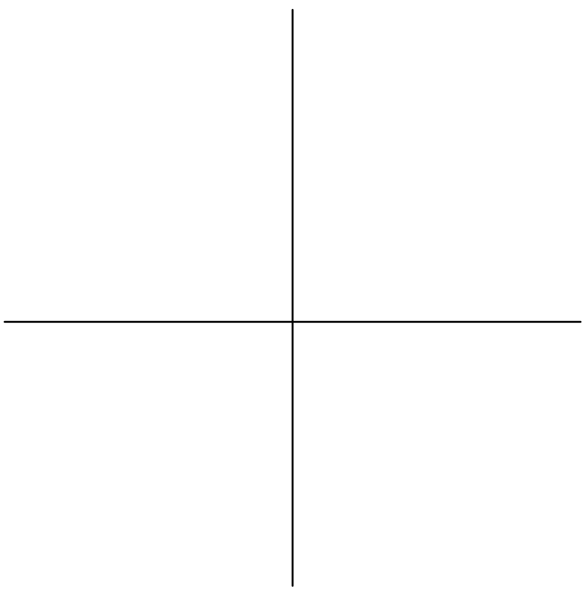
E.) Would a gain K sufficient to keep the steady-state error E less than 0.02 radians (about 1 degree) result in a stable system?

ANSWER SHEET:

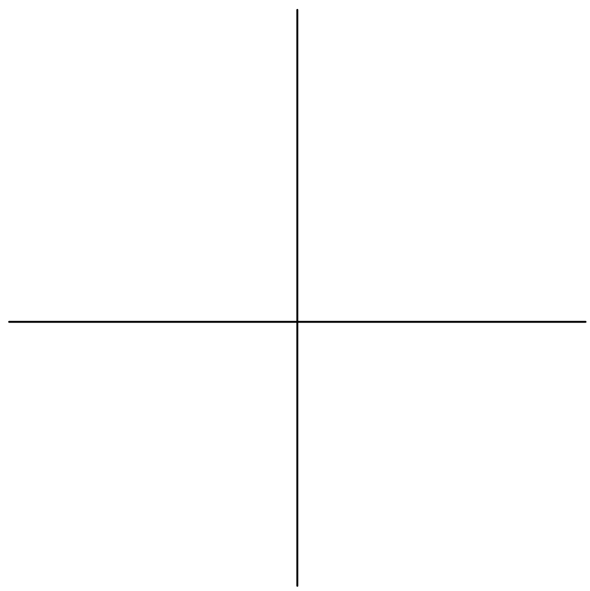
A.) K = ______________________________

B.) Root Locus Diagrams in the S-Plane:

For $K > 0$

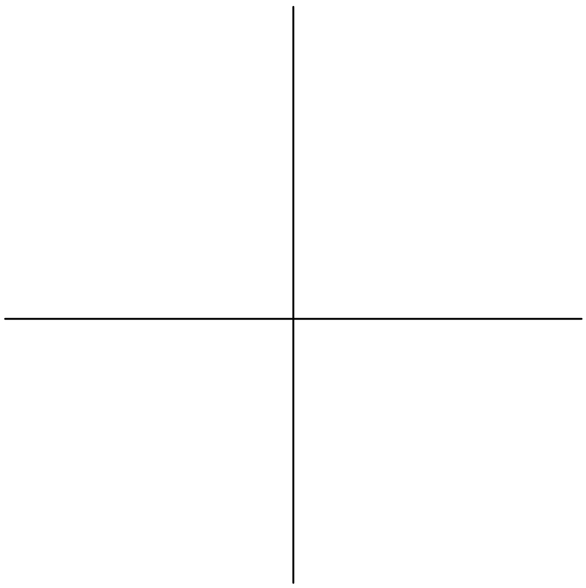


For $K < 0$

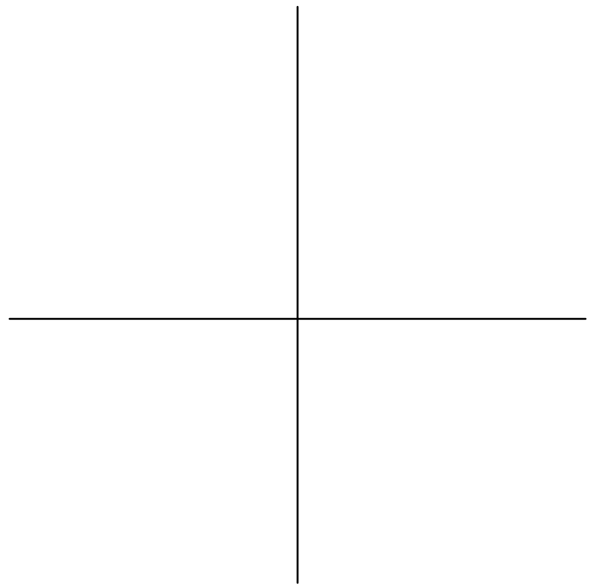


C.) Nyquist Diagram:

Your D-Contour:



Nyquist Locus in the L(s)/K plane:



D.) Ranges of K for which the autopilot is stable:

E.) Would a gain K sufficient to keep the steady-state error in C less than 0.02 radians (about 1 degree) result in a stable system? (circle your answer):

YES or NO