Controls - 2

Please note that parts 1-3 are independent of one another.

Part # 1: [30 points]

An innovative airline has opened a free bar in the tail of each of their airplanes. In order to adjust for the sudden weight shift due to the passengers rushing for drinks when it first opens, the airline has considered automating the pitch-attitude autopilot. Figure 1 shows the block diagram of the proposed arrangement. The passenger moment is modeled as a step function $M_p(s) = M_0/s$, where the maximum expected M_0 is 0.6 N·m.

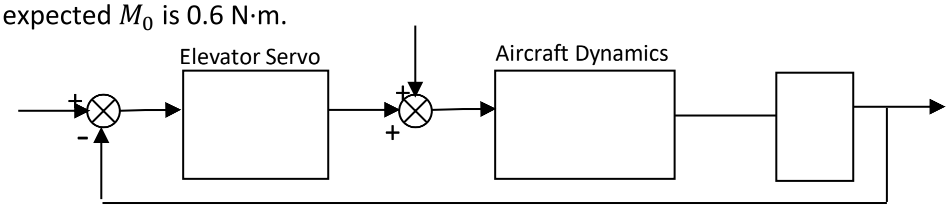

Figure 1: Aircraft stabilization control system

What value of K is required to keep the steady-state error in θ to less than –0.02 rad, assuming that $\theta_r = 0$ and the closed-loop system is stable.

Part # 2: [30 points]

Sections (a) and (b) of this question are independent of one another.

(a) (**15 points**) The Bode plot of a system G(s) is given as follows:

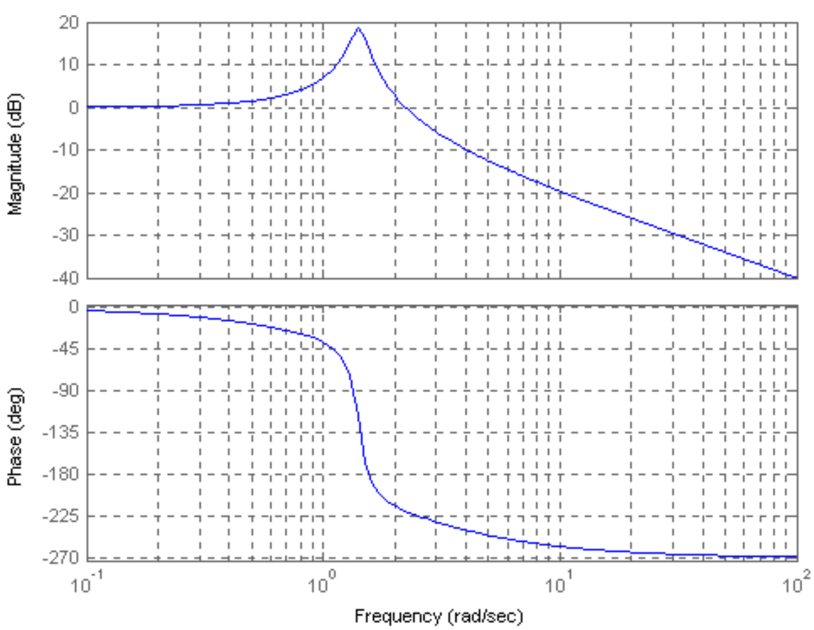

Figure 2: Bode plot of system G(s)

Calculate the steady state response for the following input: $r(t) = 3\sin(4t + \pi/2)$.

(b) (**15 points**) Consider the feedback system depicted in Figure 3.

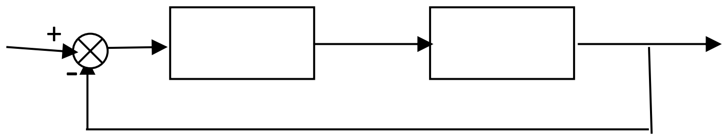

Figure 3: Feedback System

Assume that the feedback system is stable, the gain crossover frequency of $G_c G(s)$ is 4 rad/sec, and the phase margin of $G_c G(s)$ is 60°. What is the steady-state output $y(t)$ if $r(t) = \sin(4t)$?

<u>Part # 3</u> [40 points]

A control system setup is shown in Figure 4:

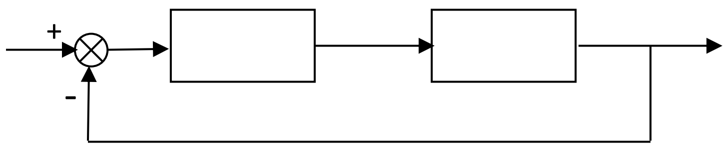

Figure 4: Feedback System

where $G_c(s) = \dfrac{K}{s(s+6)}$ and $G(s) = \dfrac{100}{(s+5)}$

(a) (**15 points**) The following specifications are to be fulfilled:

1. The steady-state error to a unit step input $r(t) = 1(t)$ is zero.
2. The closed loop system is stable for any positive value of K.

Can the given controller fulfill these specifications? Explain your answer using the Root Locus.

(b) (**10 points**) It is proposed to replace the controller with the following: $G_c(s) = \dfrac{K(s+9)}{s(s+6)}$

Is it possible now to fulfill the specifications? Explain your answer using the Root Locus.

(c) (**15 points**) Fig. 5 depicts the closed-loop response of the system to a *unit ramp* input in $r(t)$ (with the controller from section (b)). Find the value of K that corresponds to this response.

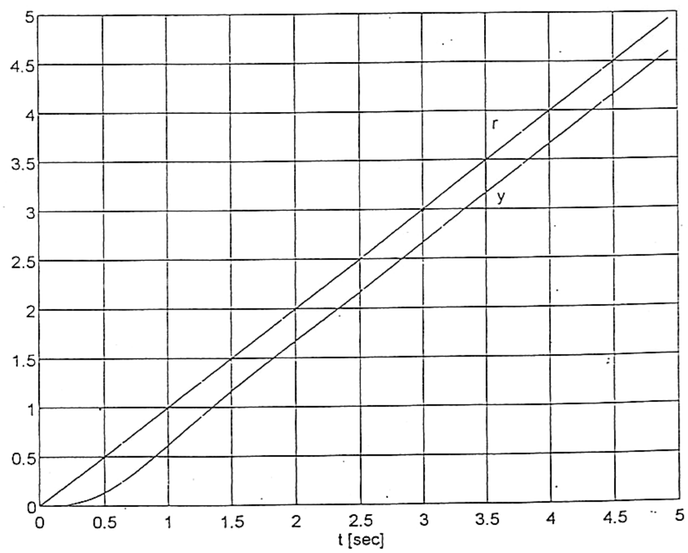

Figure 5: Closed-loop response of the system to a *unit ramp* input