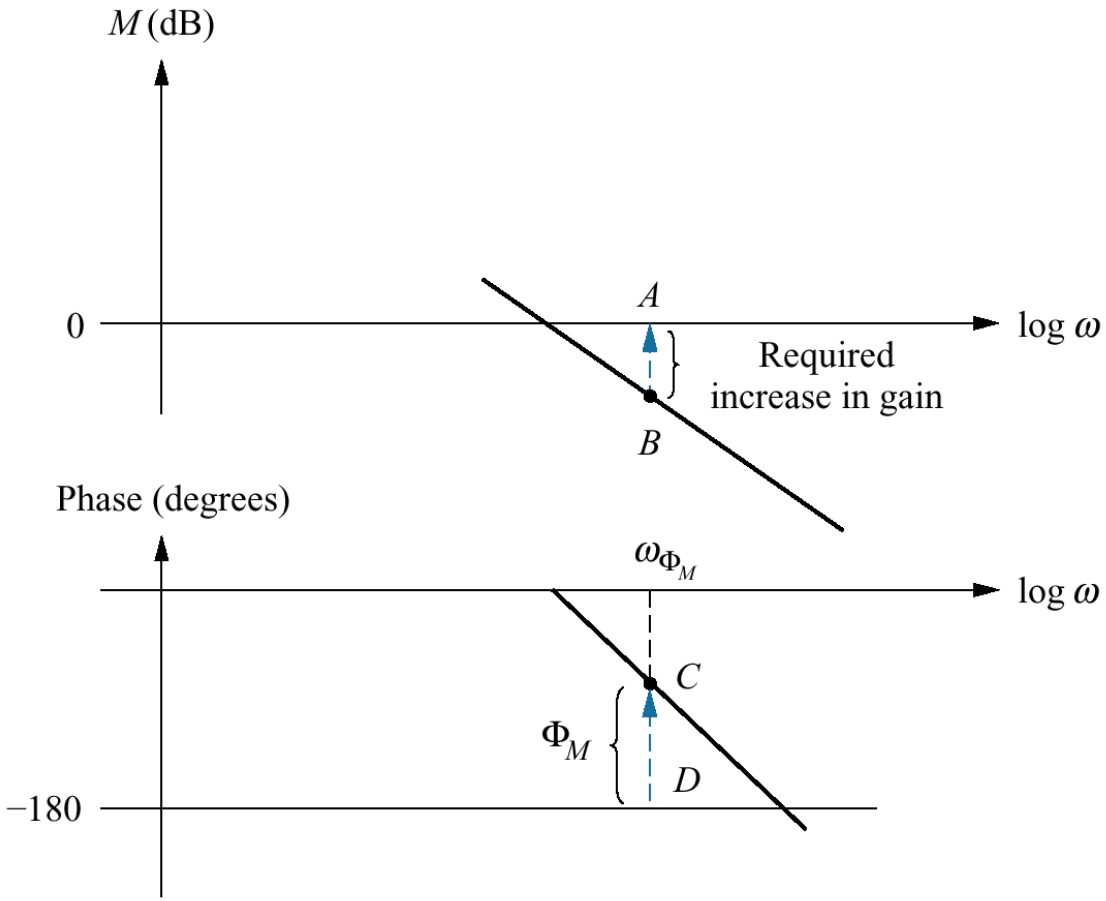
Figure 11.1
Bode plots showing gain adjustment for a desired phase margin



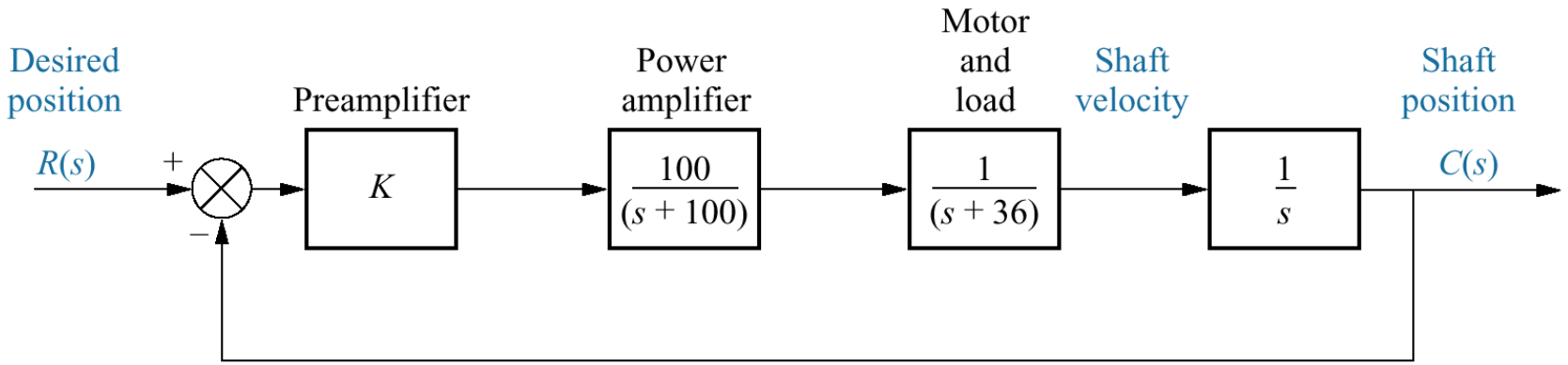


Figure 11.2
System for Example 11.1

Figure 11.3
Bode magnitude and phase plots for Example 11.1

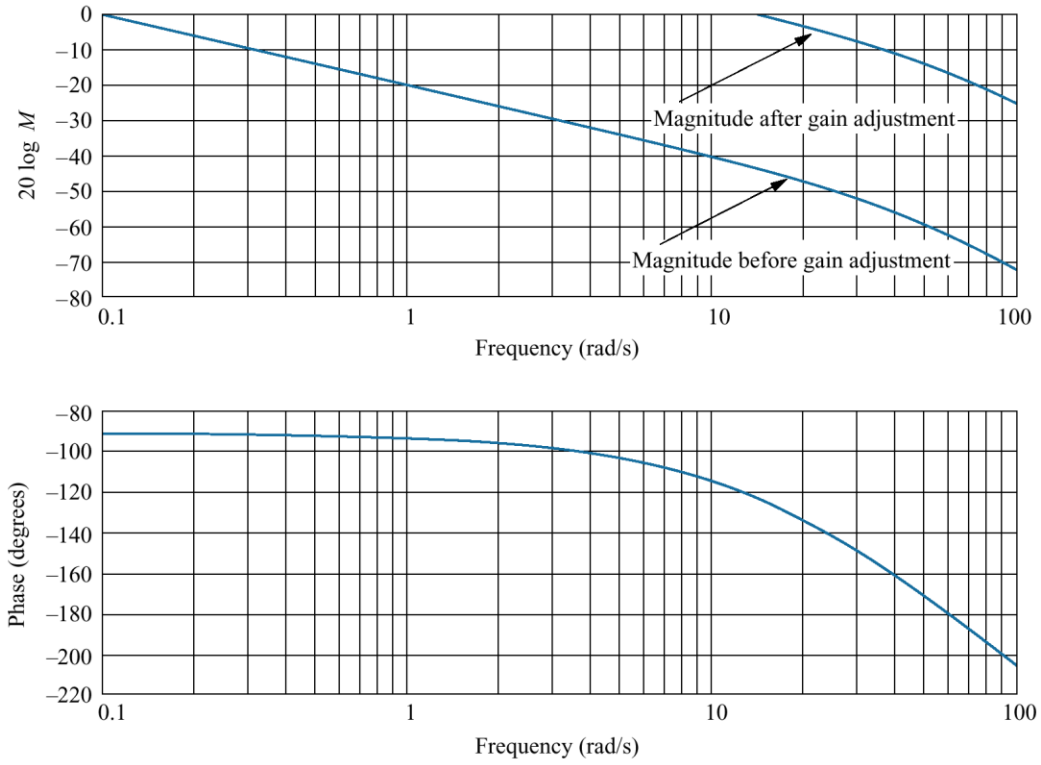


Table 11.1
Characteristics of gain-compensated system of Example 11.1

Parameter	Proposed Specification	Actual Value
K_v	—	16.22
Phase margin	59.2°	59.2°
Phase-margin frequency	—	14.8 rad/s
Percent overshoot	9.5	10
Peak time	—	0.18 second

Figure 11.4
Visualizing lag compensation

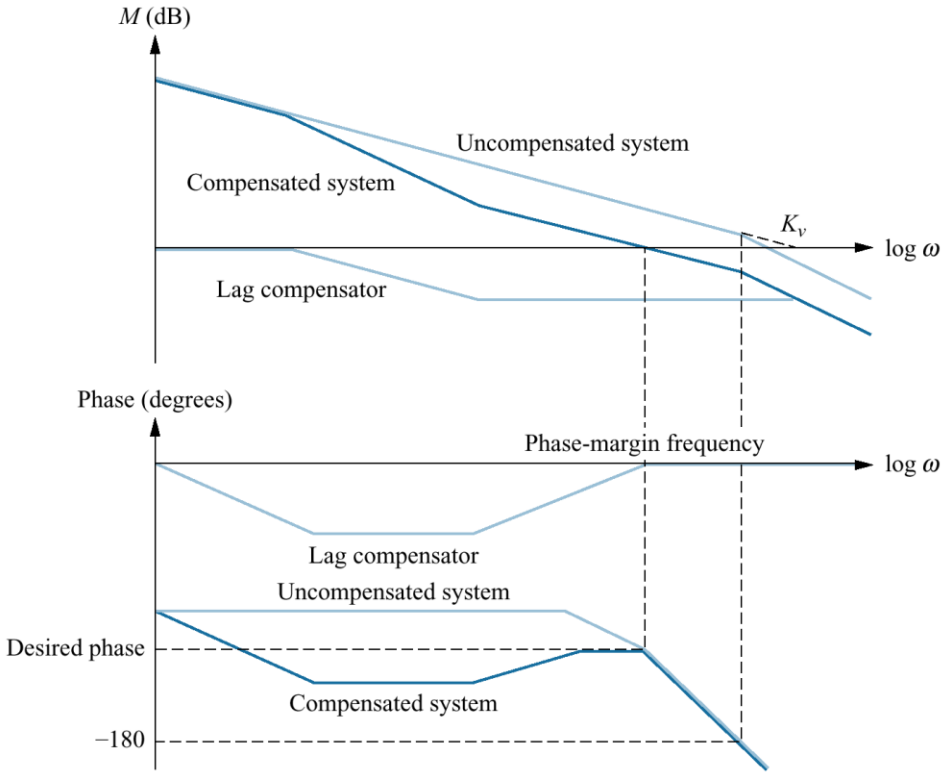


Figure 11.5
Frequency response plots of a lag compensator, $G_c(s) = (s + 0.1)/(s + 0.01)$

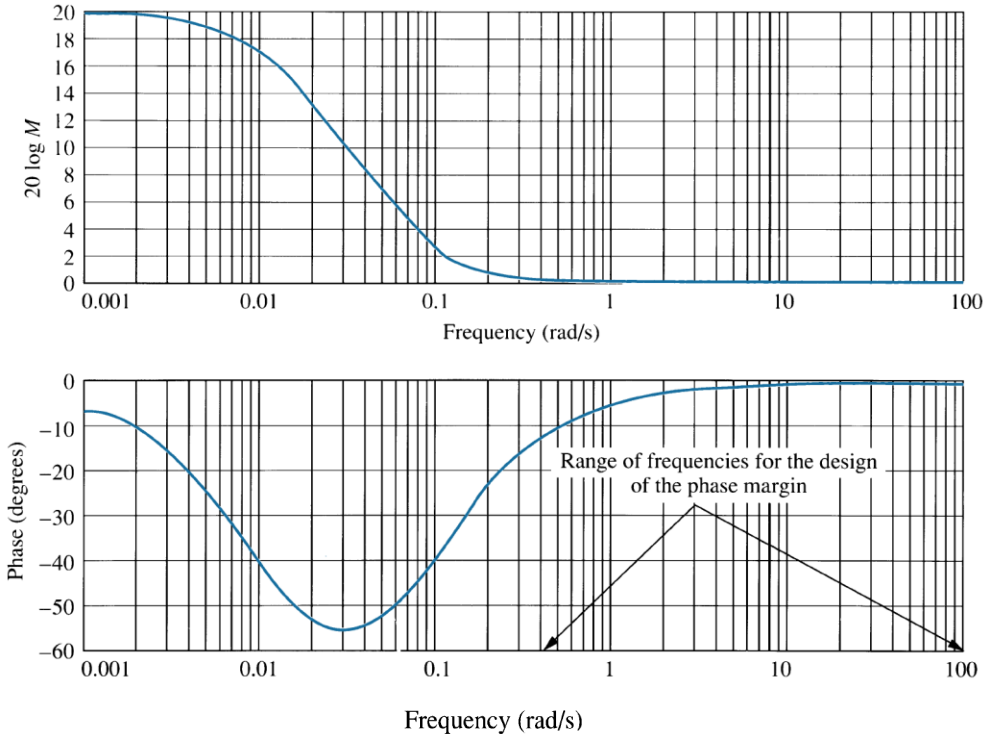


Figure 11.6
Bode plots for
Example 11.2

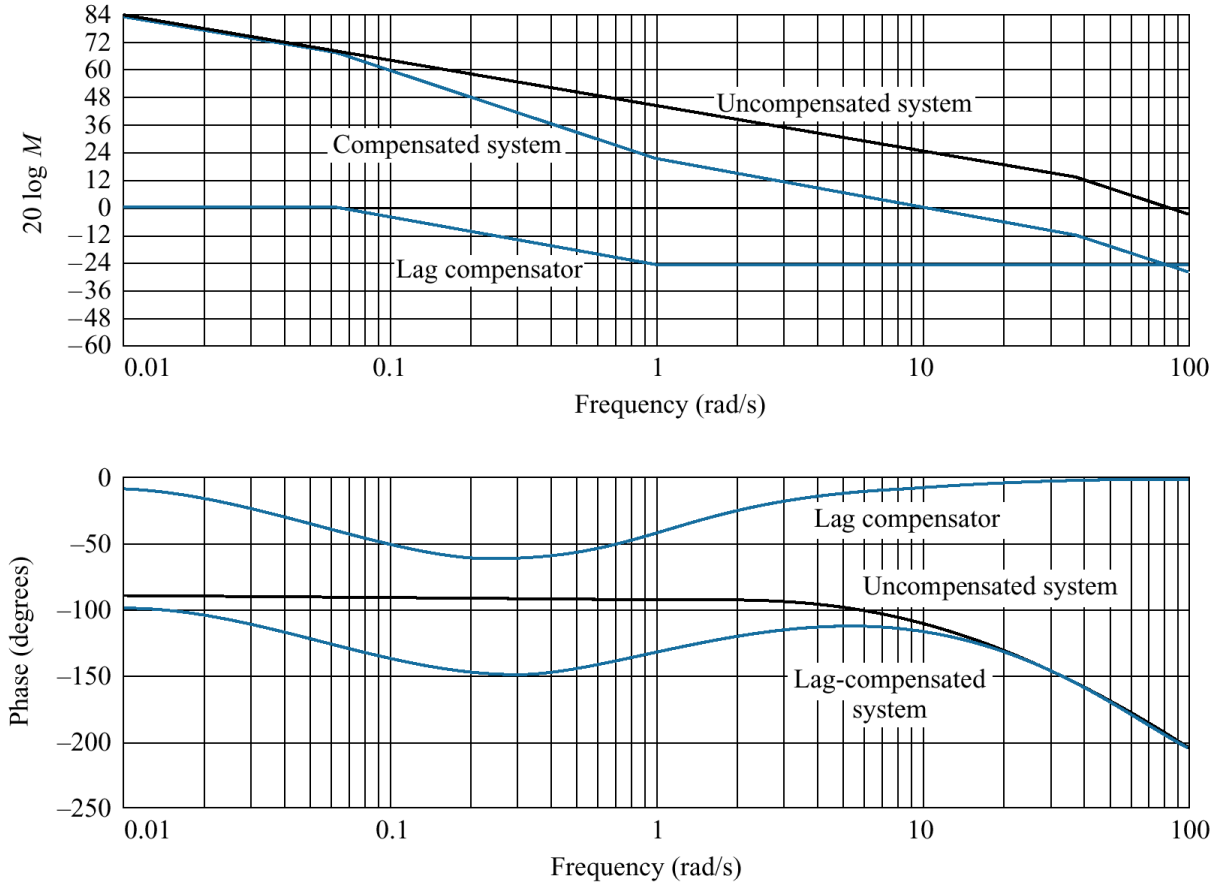


Table 11.2
Characteristics of the lag-compensated system of Example 11.2

Parameter	Proposed Specification	Actual Value
K_v	162.2	161.5
Phase margin	59.2°	62°
Phase-margin frequency	—	11 rad/s
Percent overshoot	9.5	10
Peak time	—	0.25 second

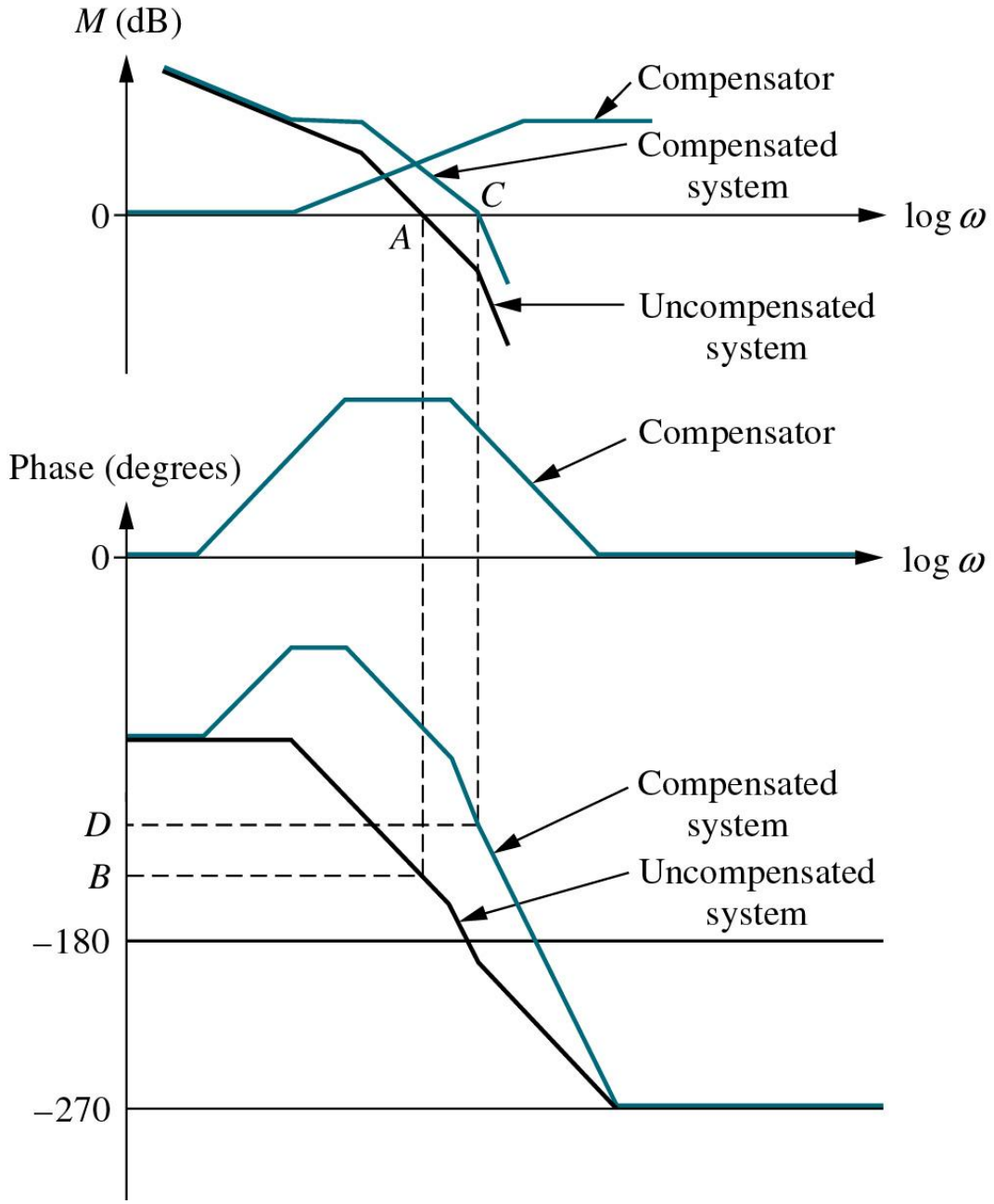
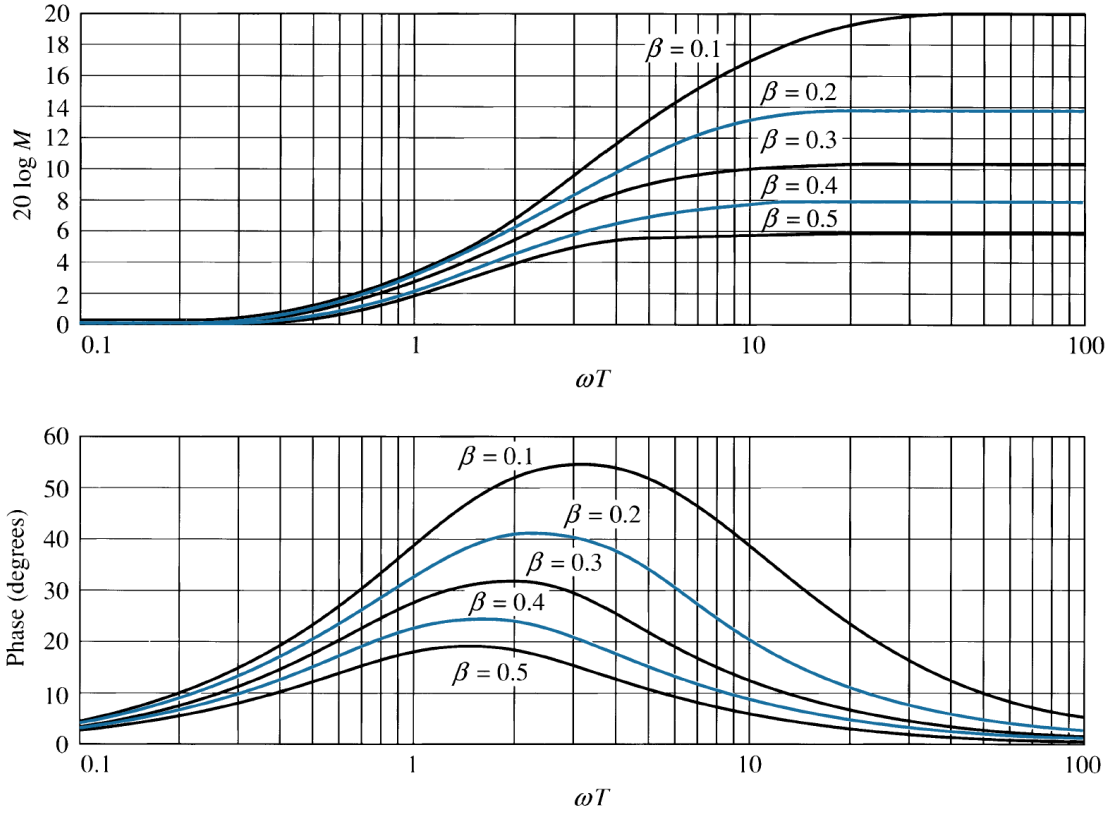


Figure 11-7 (p. 701)
Visualizing lead compensation

Figure 11.8
Frequency response of a lead compensator

$$G_c(s) = [1/\beta][(s + 1/T)/(s + 1/\beta T)]$$



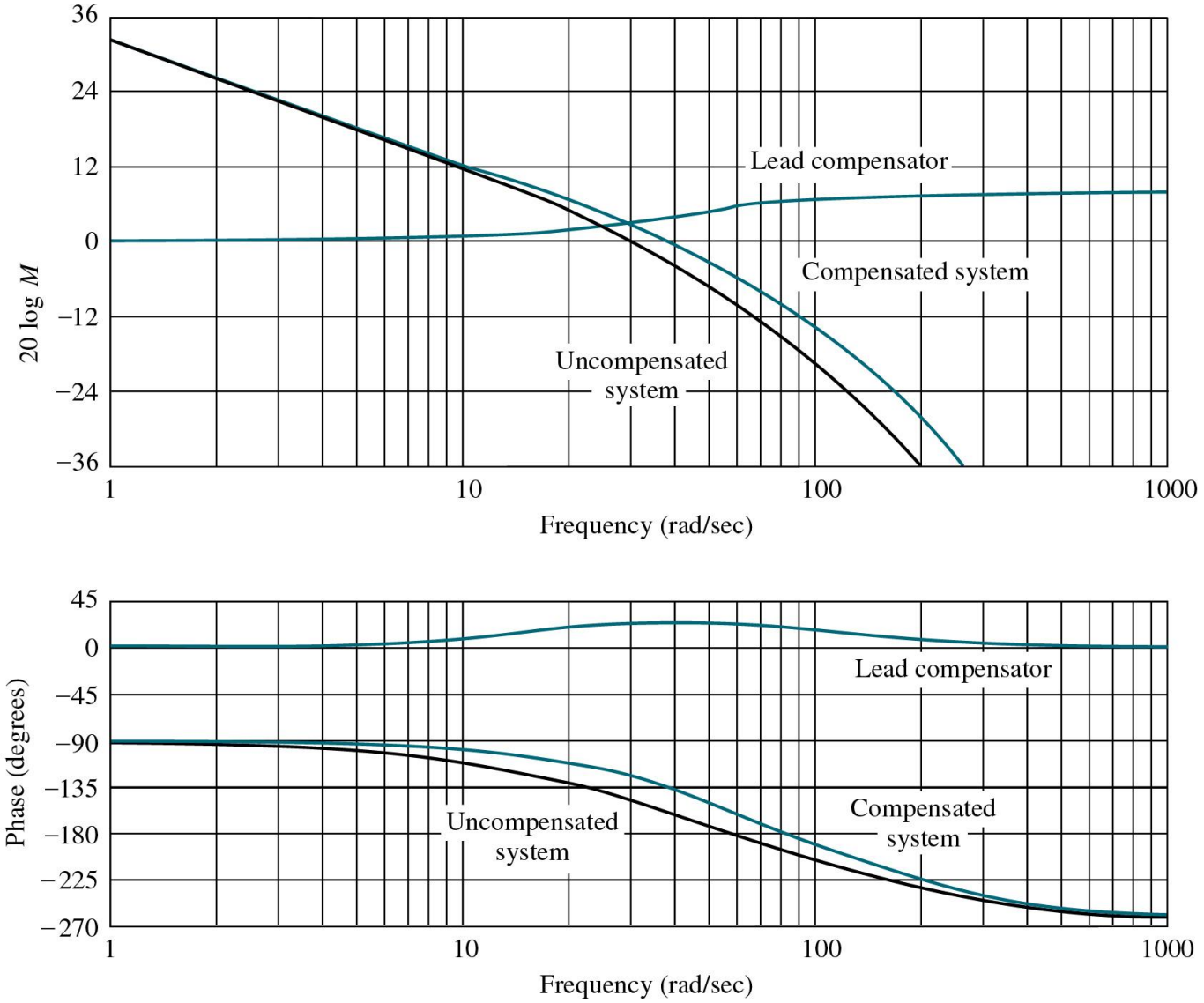
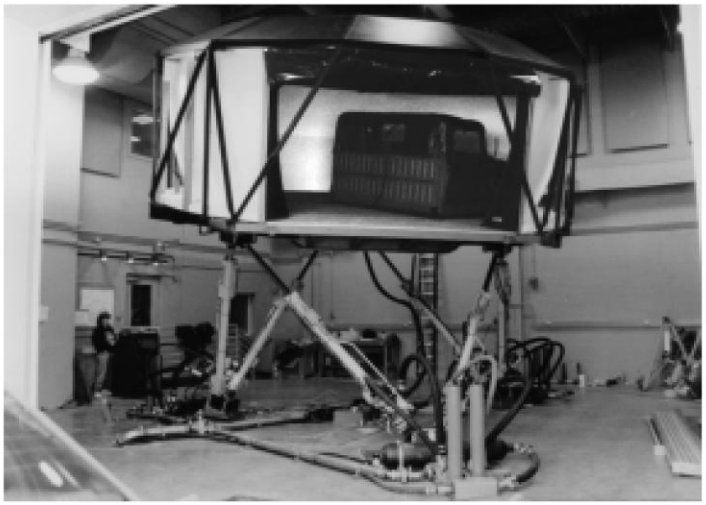


Figure 11-9 (p. 705)

Bode plots for lead compensation in Example 11.3

Figure 11.10
a. The Iowa Driving Simulator;
b. test driving the simulator with its realistic graphics



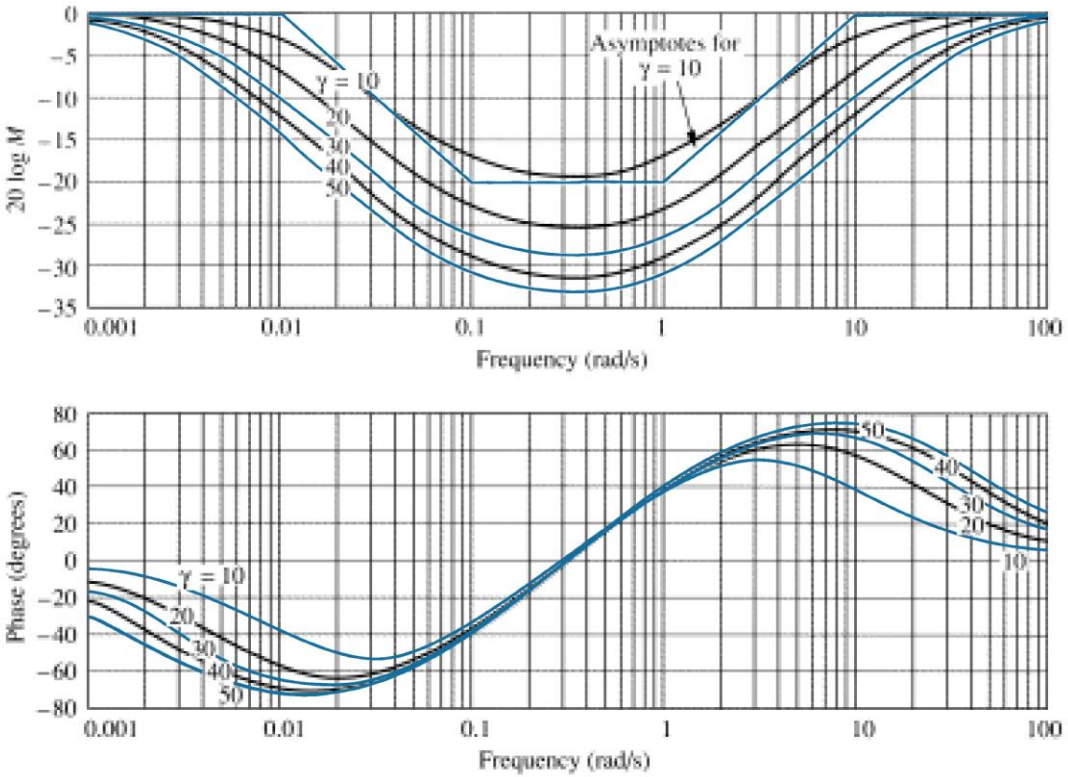
(*a*)

(*b*)

Courtesy of Jim Stoner, The University of Iowa.

Figure 11.11
Sample frequency response curves for a lag-lead compensator, $G_c(s)$ =

$$\frac{[(s+1)(s+0.1)]}{[(s+\gamma)(s+\frac{0.1}{\gamma})]}$$



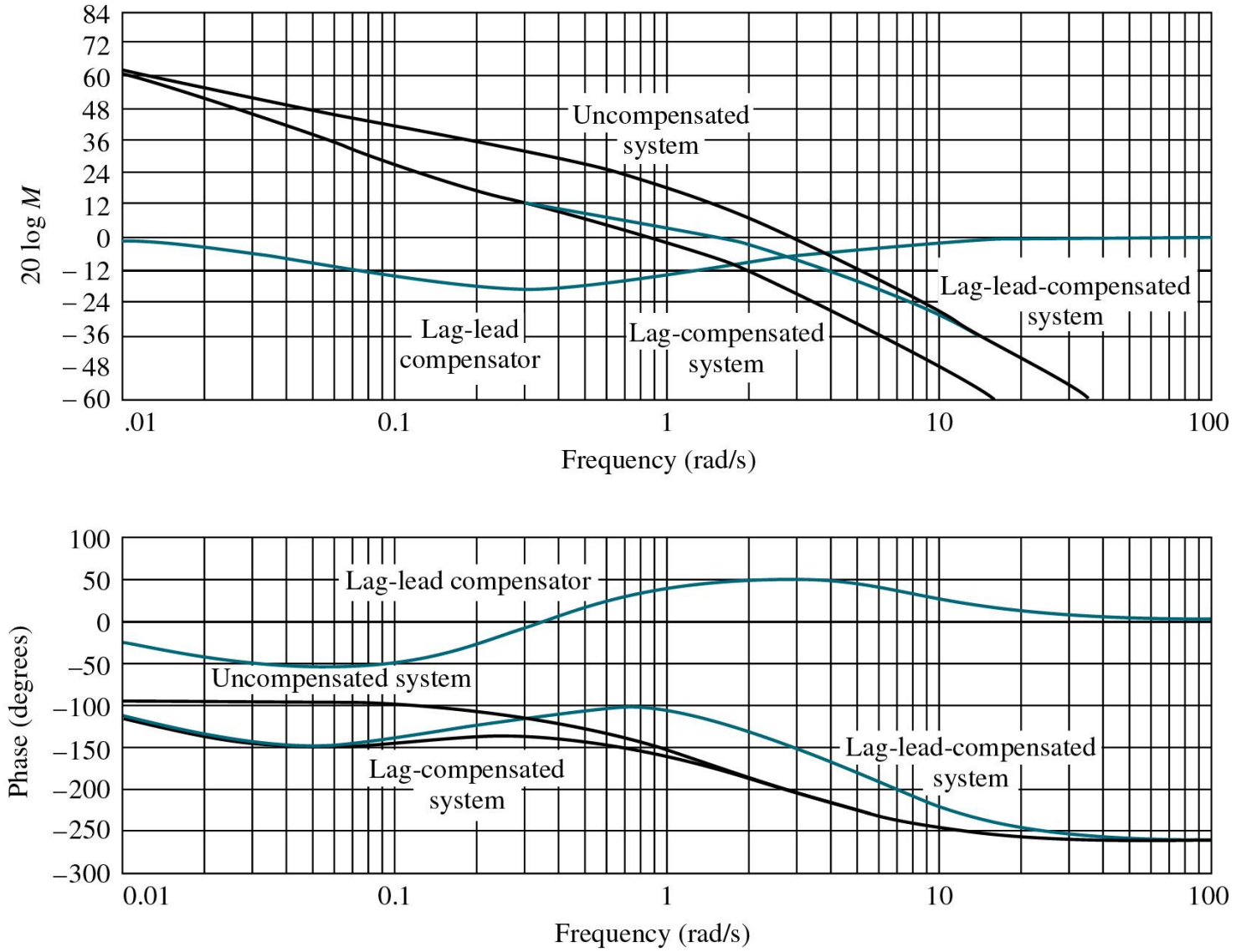


Figure 11-12 (p. 711)

Bode plots for lag-lead compensation in Example 11.4

Table 11.3 Characteristics of the lead-compensated system of Example 11.3

Parameter	Proposed Specification	Actual Gain-Compensated Value	Actual Lead-Compensated Value
K_v	40	40	40
Phase margin	48.1°	34°	45.5°
Phase-margin frequency	—	29.6 rad/s	39 rad/s
Closed-loop bandwidth	46.6 rad/s	50 rad/s	68.8 rad/s
Percent overshoot	20	37	22.6
Peak time	0.1 second	0.1 second	0.075 second

Table 11.3
Characteristics of the lead-compensated system of Example 11.3

Table 11.4 Characteristics of gain-compensated system of Example 11.4

Parameter	Proposed Specification	Actual Value
K_v	12	12
Phase margin	55°	59.3°
Phase-margin frequency	—	1.63 rad/s
Closed-loop bandwidth	2.29 rad/s	3 rad/s
Percent overshoot	13.25	10.2
Peak time	2.0 seconds	1.61 seconds

Table 11.4
Characteristics of gain-compensated system of Example 11.4

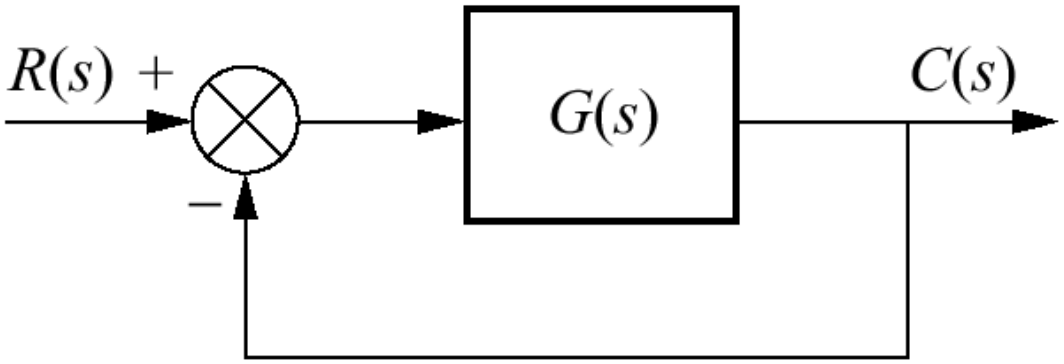


Figure P11.1

Figure P11.2
Towed-vehicle roll control

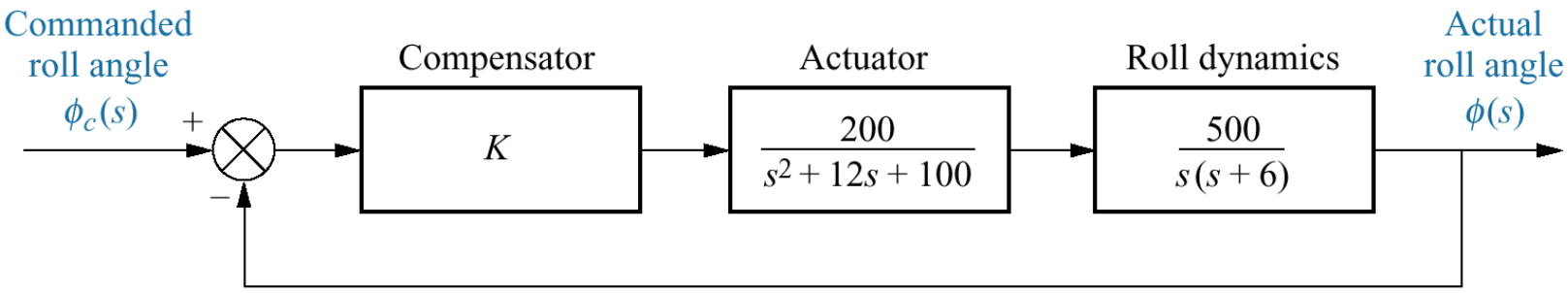


Figure P11.3

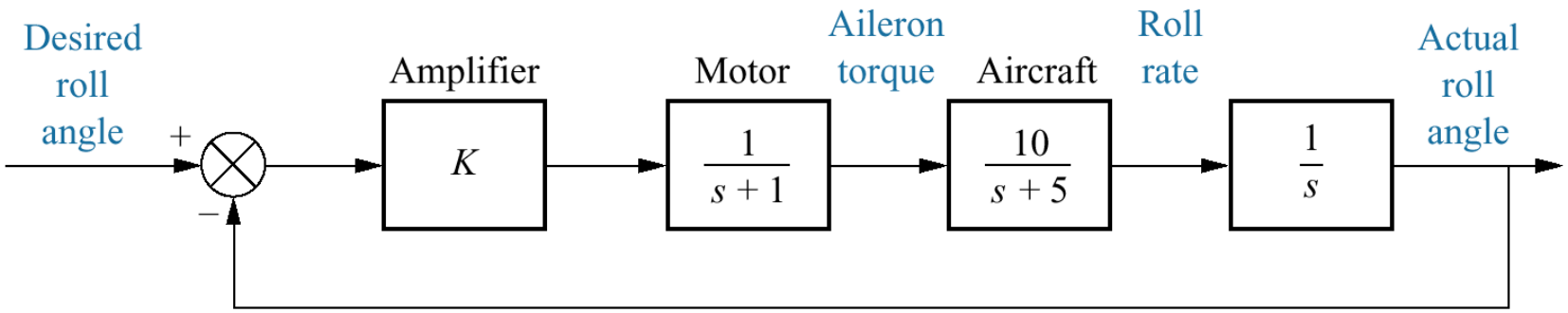
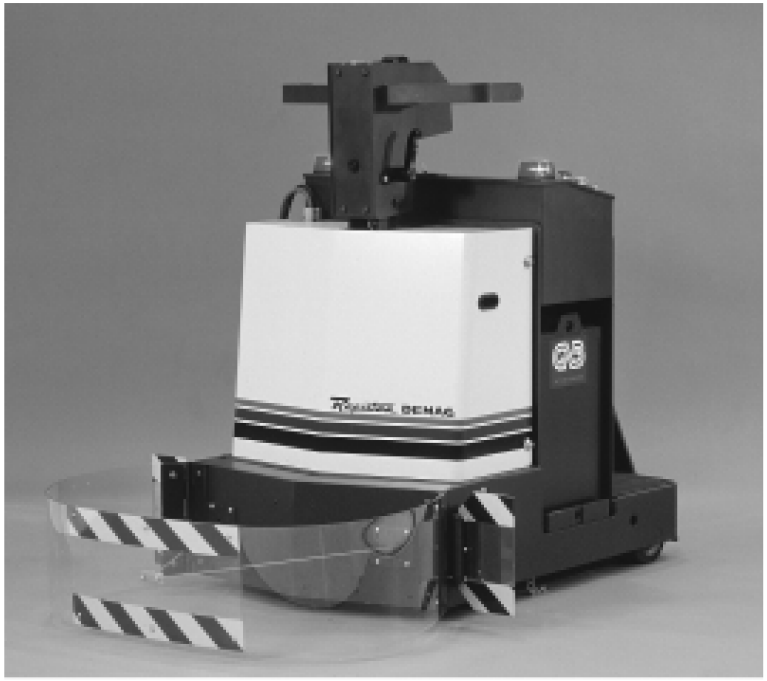

Desired roll angle
+
−
Amplifier
K
Motor
1
s + 1
Aileron torque
Aircraft
10
s + 5
Roll rate
1
s
Actual roll angle

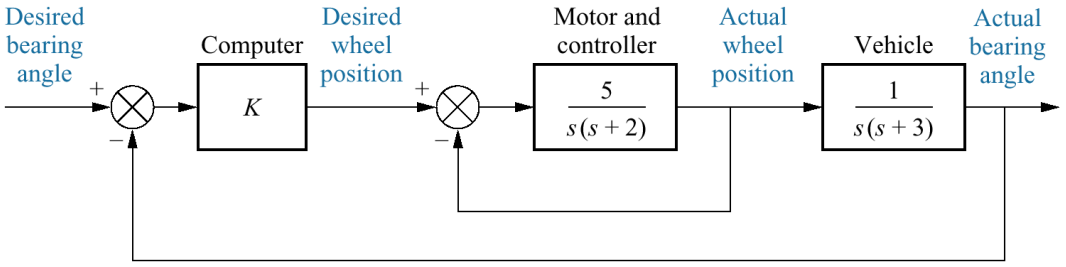
Figure P11.4

a. A self-guided vehicle;
b. simplified block diagram

Courtesy of Rapistan Demag Corp.

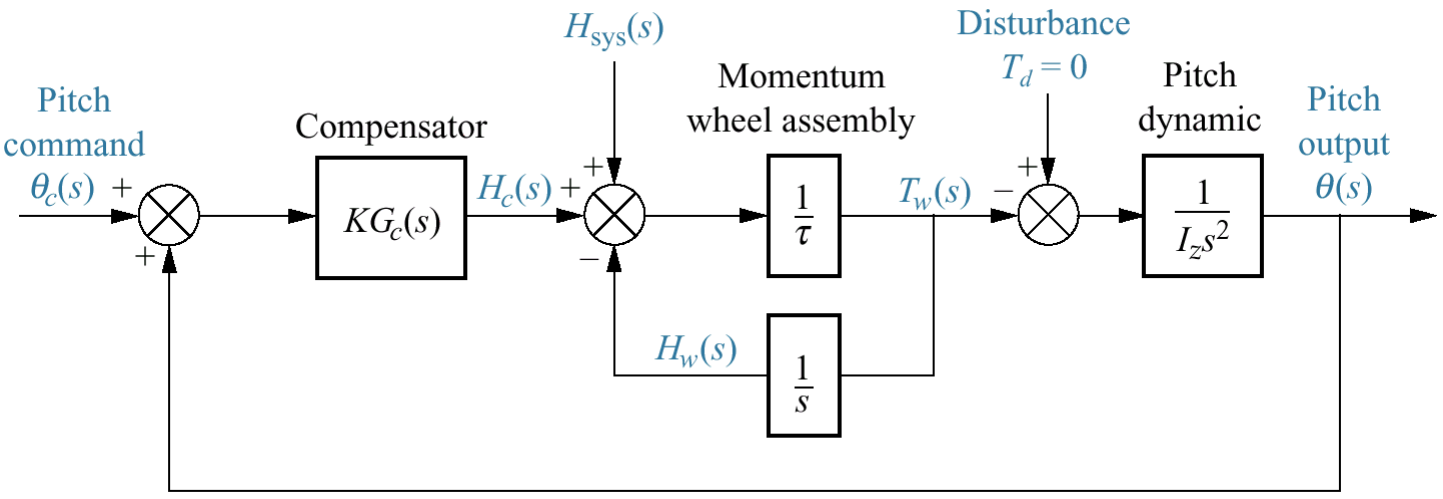


(*a*)



(*b*)

Figure P11.5


Pitch command
$\theta_c(s)$
+
+
Compensator
$KG_c(s)$
$H_c(s)$
+
+
$H_{sys}(s)$
Momentum wheel assembly
$\frac{1}{\tau}$
$T_w(s)$
Disturbance
$T_d = 0$
+
−
Pitch dynamic
$\frac{1}{I_z s^2}$
Pitch output
$\theta(s)$
$H_w(s)$
$\frac{1}{s}$