ME 132, Spring 2005, Quiz 2

Name:

# 1	# 2	TOTAL
18	32	80

NOTE: Any unmarked summing junctions are positively signed (+).

1. Consider the closed loop system shown ~~below~~.

The transfer function for the controller is

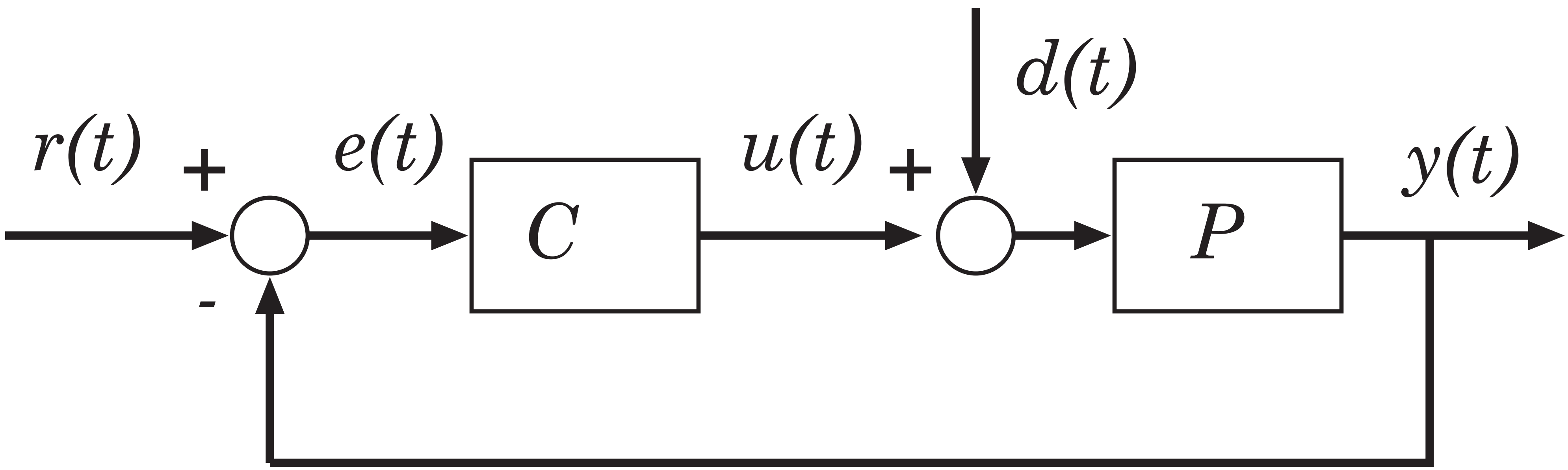
$$C(s) = \frac{s + \frac{25}{3}}{s} \tag{1}$$

The transfer function for the process is

$$P(s) = \frac{3}{s+5} \tag{2}$$

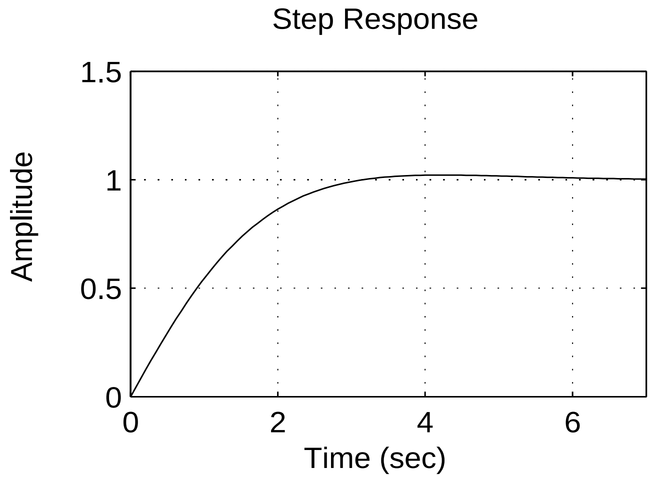
(a) What is the closed loop transfer function from r to y?

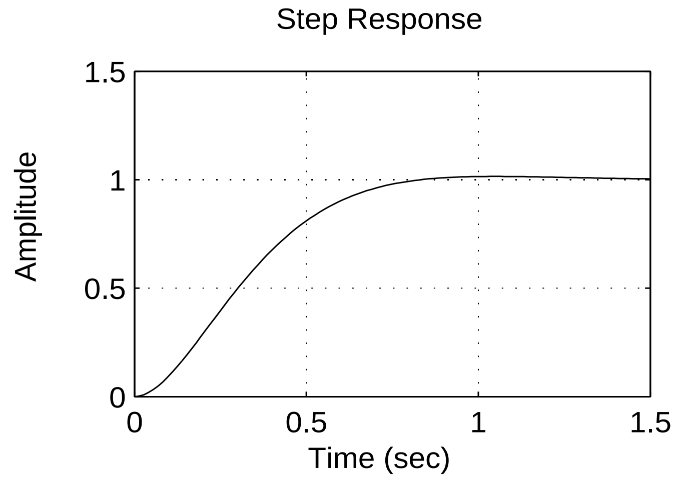
(b) What is the closed loop transfer function from d to y?

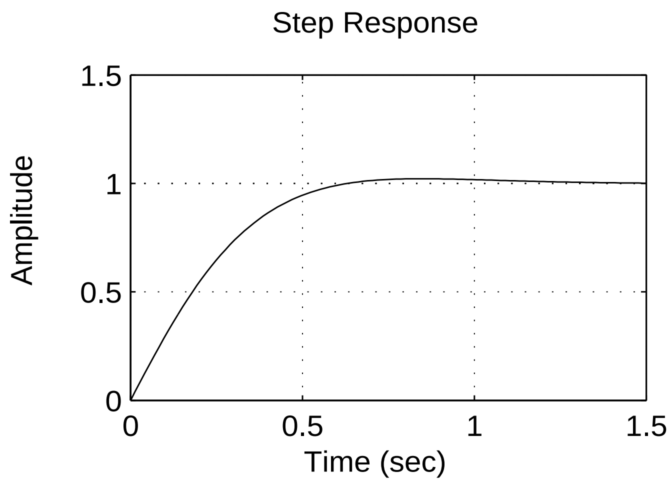


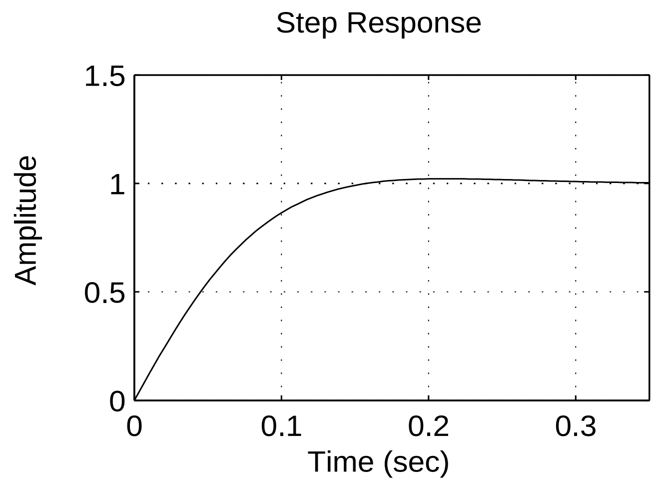
r(t)
+
-
e(t)
C
u(t)
+
d(t)
P
y(t)

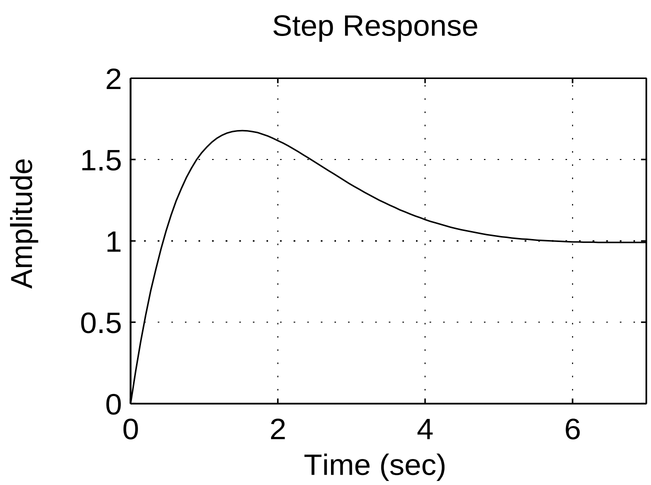
(c) Assume all initial conditions are zero. Suppose that the reference input, r, is a unit step function, and the disturbance input, d is identically zero. Shown below are several possible responses for the output variable y. Only one of them is correct. Clearly mark the correct one. (Show work/reasoning on next page).

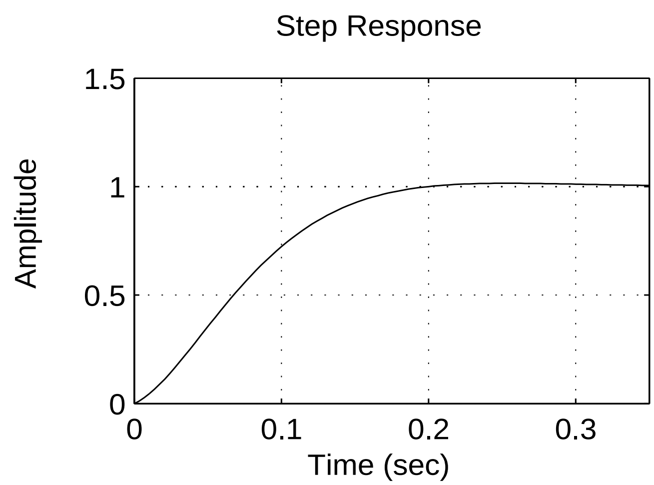




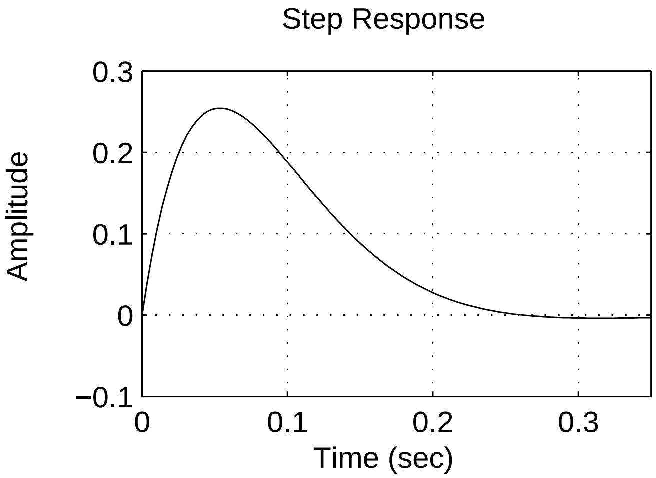


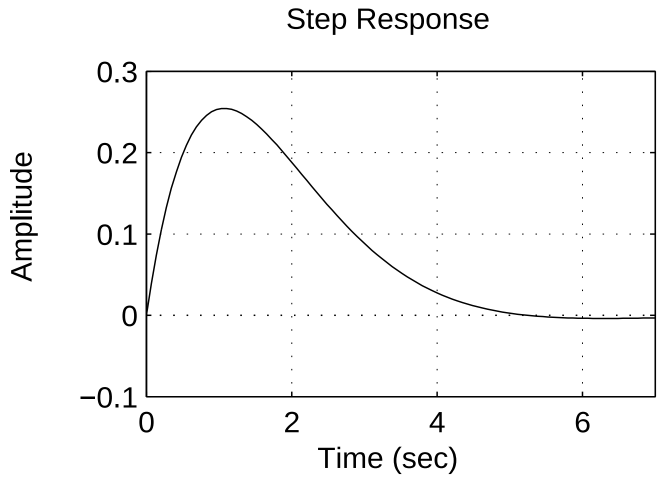


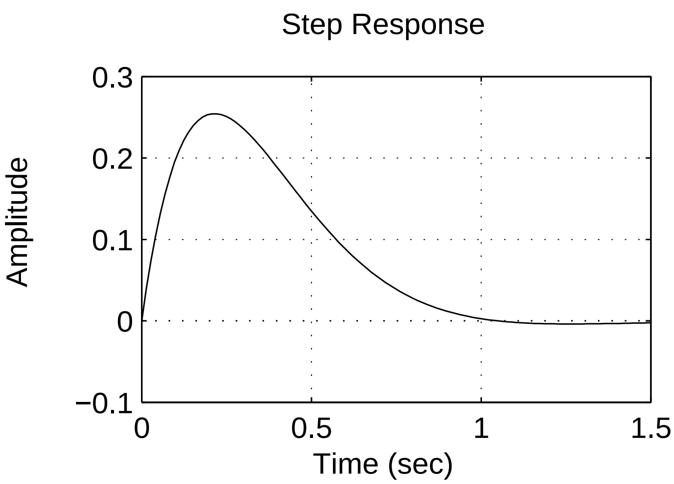


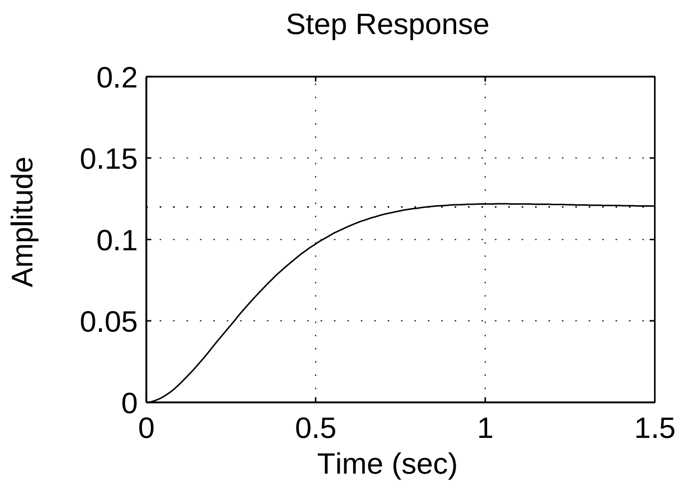


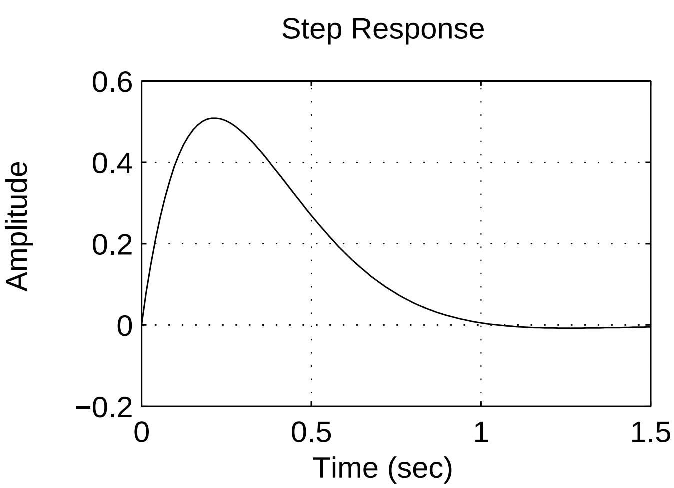
(d) Assume all initial conditions are zero. Suppose that the disturbance input, d, is a unit step function, and the reference input, r, is identically zero. Shown below are several possible responses for the output variable y. Only one of them is correct. Clearly mark the correct one. (Show work/reasoning on next page).

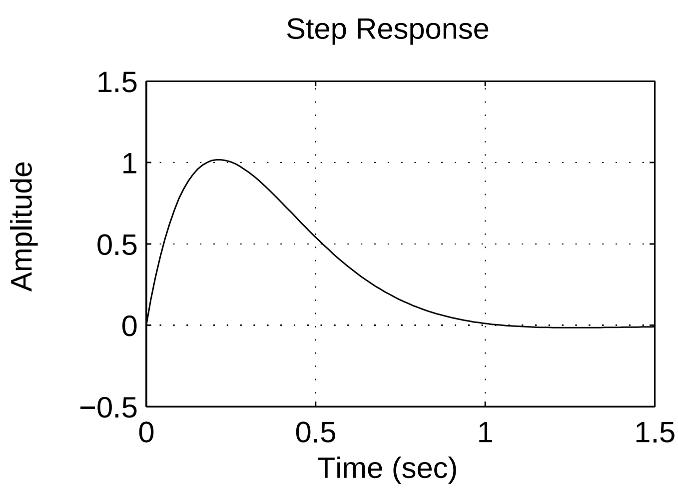




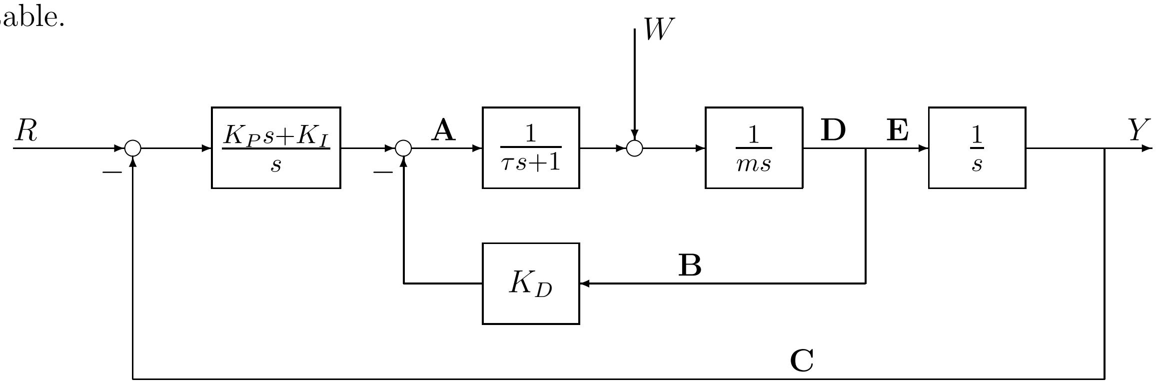








2. Consider the diagram below. Here, $m = 2$ and $\tau = 0.0312$. If we choose $K_D = 16, K_P = 52.48, K_I = 51.2$ it is possible (you do not need to) to verify that the closed-loop system is stable.



In order to assist you in the question below, Bode plots of certain transfer functions listed below are given on pages 10-15 (not all may be useful...).

$$H_1(s) = \frac{K_P s + K_I}{m\tau s^4 + ms^3 + K_D s^2} \qquad H_2(s) = \frac{K_D s^2}{m\tau s^4 + ms^3 + K_P s + K_I}$$

$$H_3(s) = \frac{K_D s^2 + K_P s + K_I}{m\tau s^4 + ms^3 + K_D s^2 + K_P s + K_I} \qquad H_4(s) = \frac{K_D s^2 + K_P s + K_I}{m\tau s^4 + ms^3}$$

$$H_5(s) = \frac{K_D}{m\tau s^2 + ms} \qquad H_6(s) = \frac{K_P s + K_I}{m\tau s^4 + ms^3}$$

Using the graphs (estimate values as best as you can...), answer the following margin questions. Explain any work you do, and make relevant marks on the Bode plots that you use in your calculations.

(a) What is the gain margin at location **A**? (Hint – first determine what is the appropriate L for margin calculations at **A**, match with the H's, and do calculation from supplied graphs).

(b) What is the time-delay margin at location **A**?

(c) What is the gain margin at location **B**?

(d) What is the time-delay margin at location **B**?

(e) What is the gain margin at location **C**?

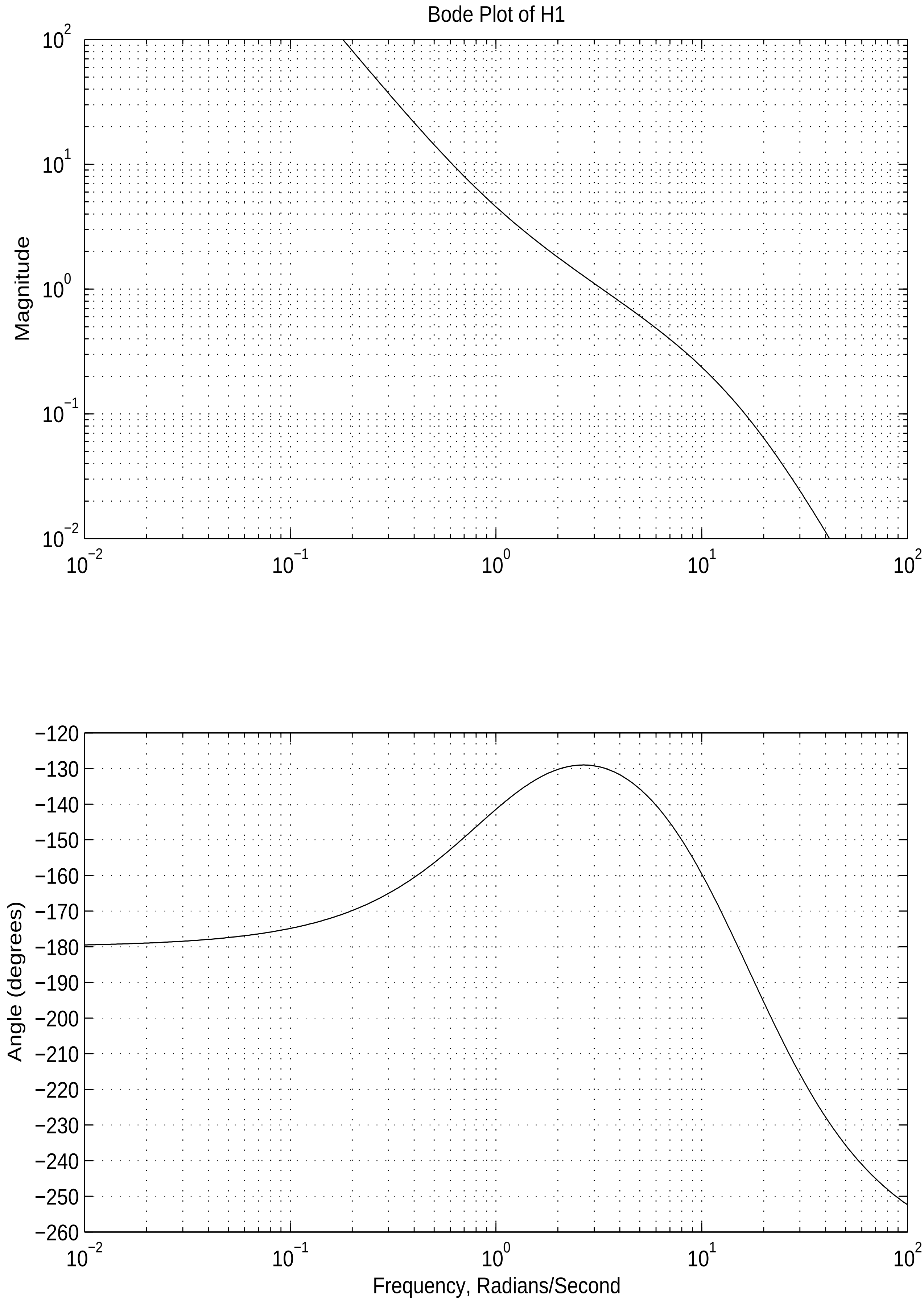
(f) What is the time-delay margin at location **C**?

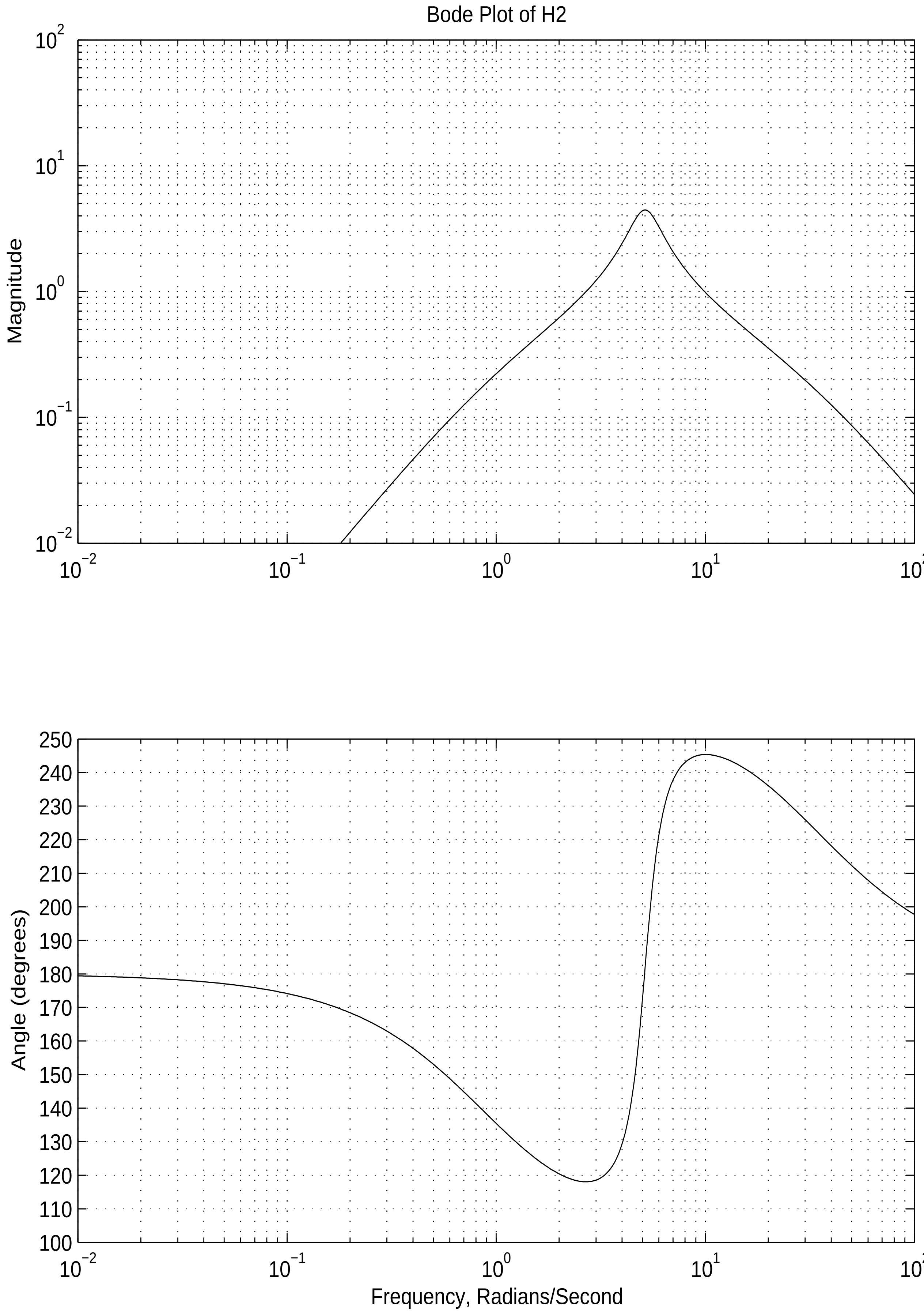
(g) What is the gain margin at location **D**?

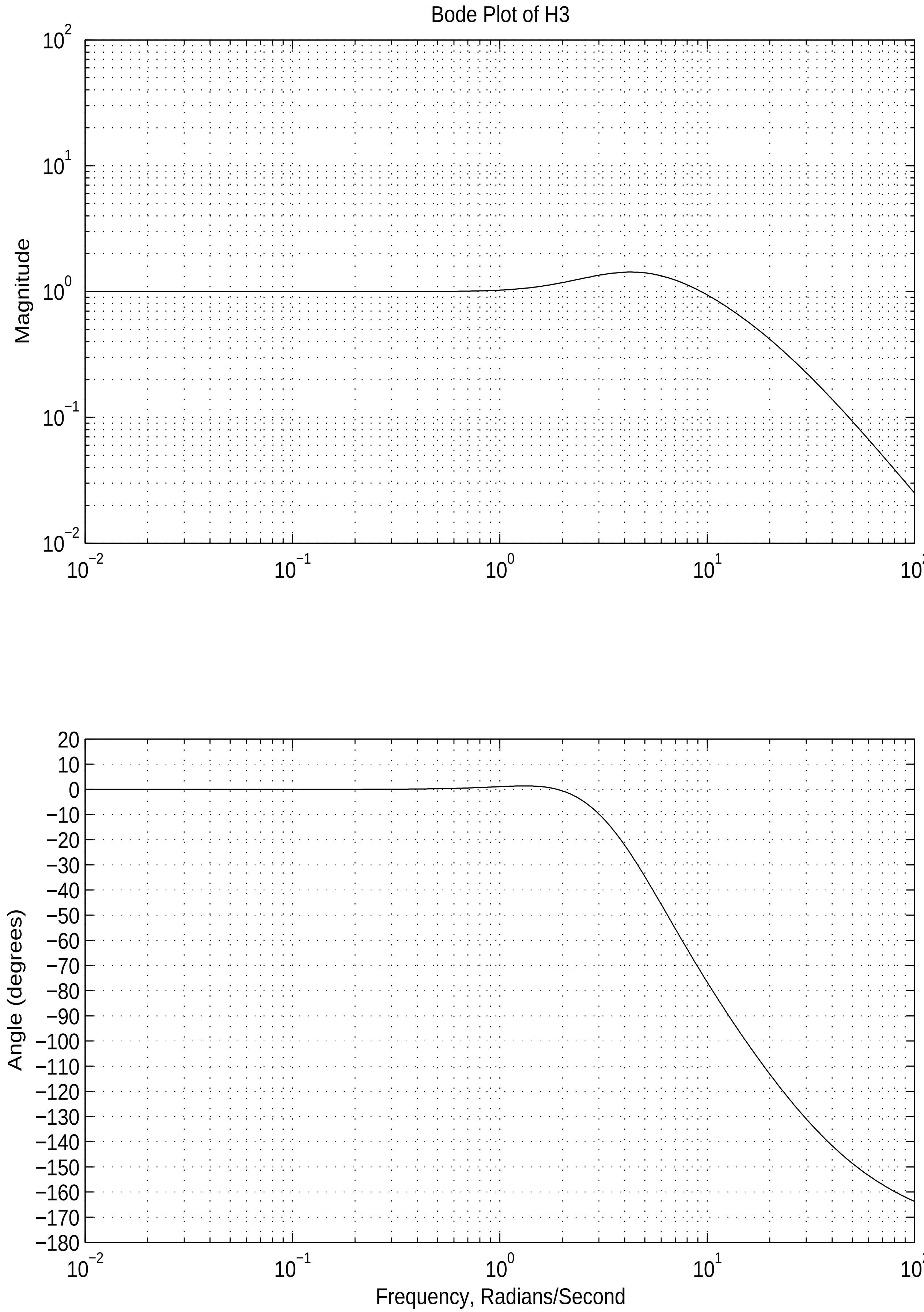
(h) What is the time-delay margin at location **D**?

(i) What is the gain margin at location **E**?

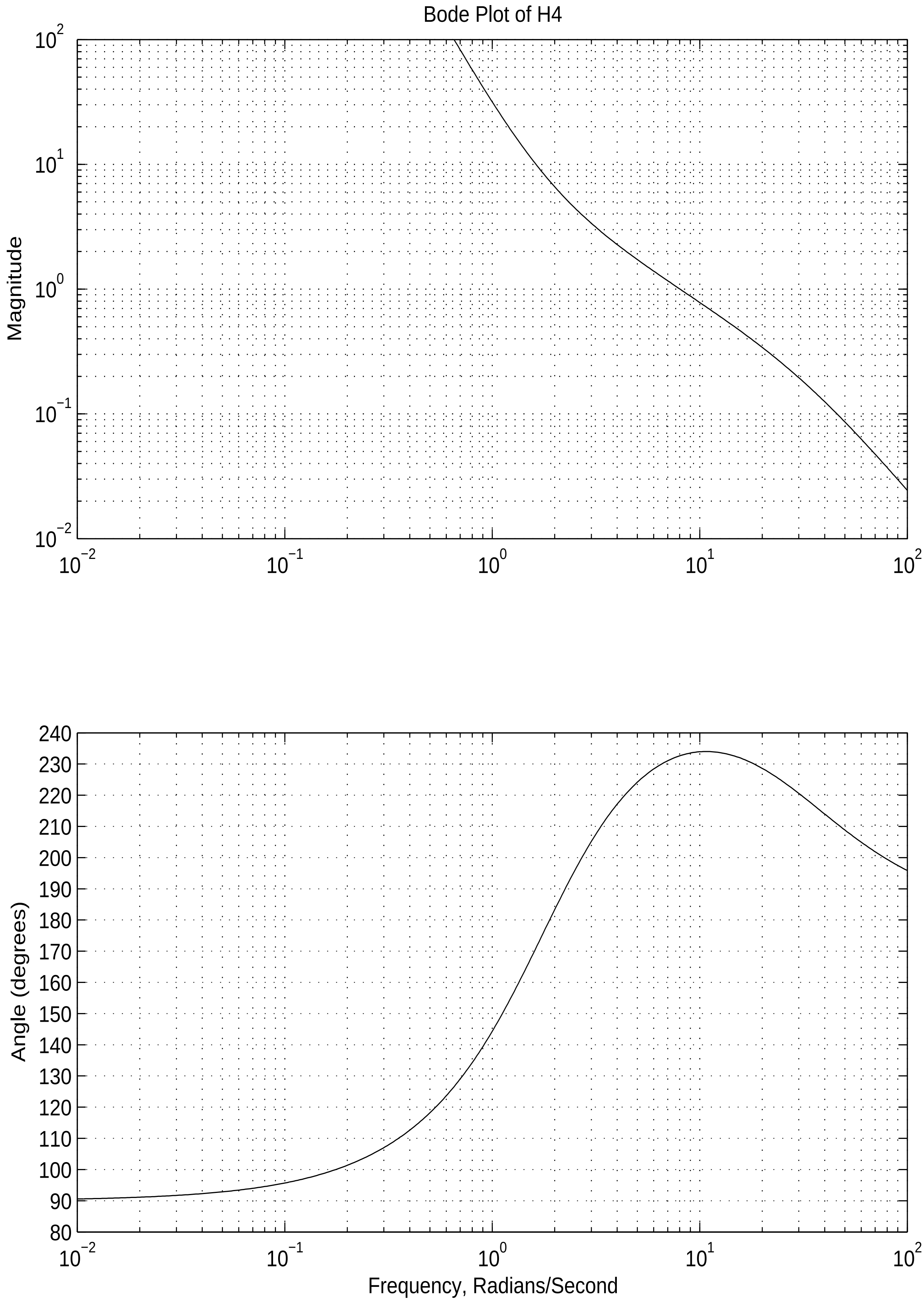
(j) What is the time-delay margin at location **E**?


Bode Plot of H1
Magnitude
10^2
10^1
10^0
10^−1
10^−2
10^−2
10^−1
10^0
10^1
10^2
Angle (degrees)
−120
−130
−140
−150
−160
−170
−180
−190
−200
−210
−220
−230
−240
−250
−260
Frequency, Radians/Second

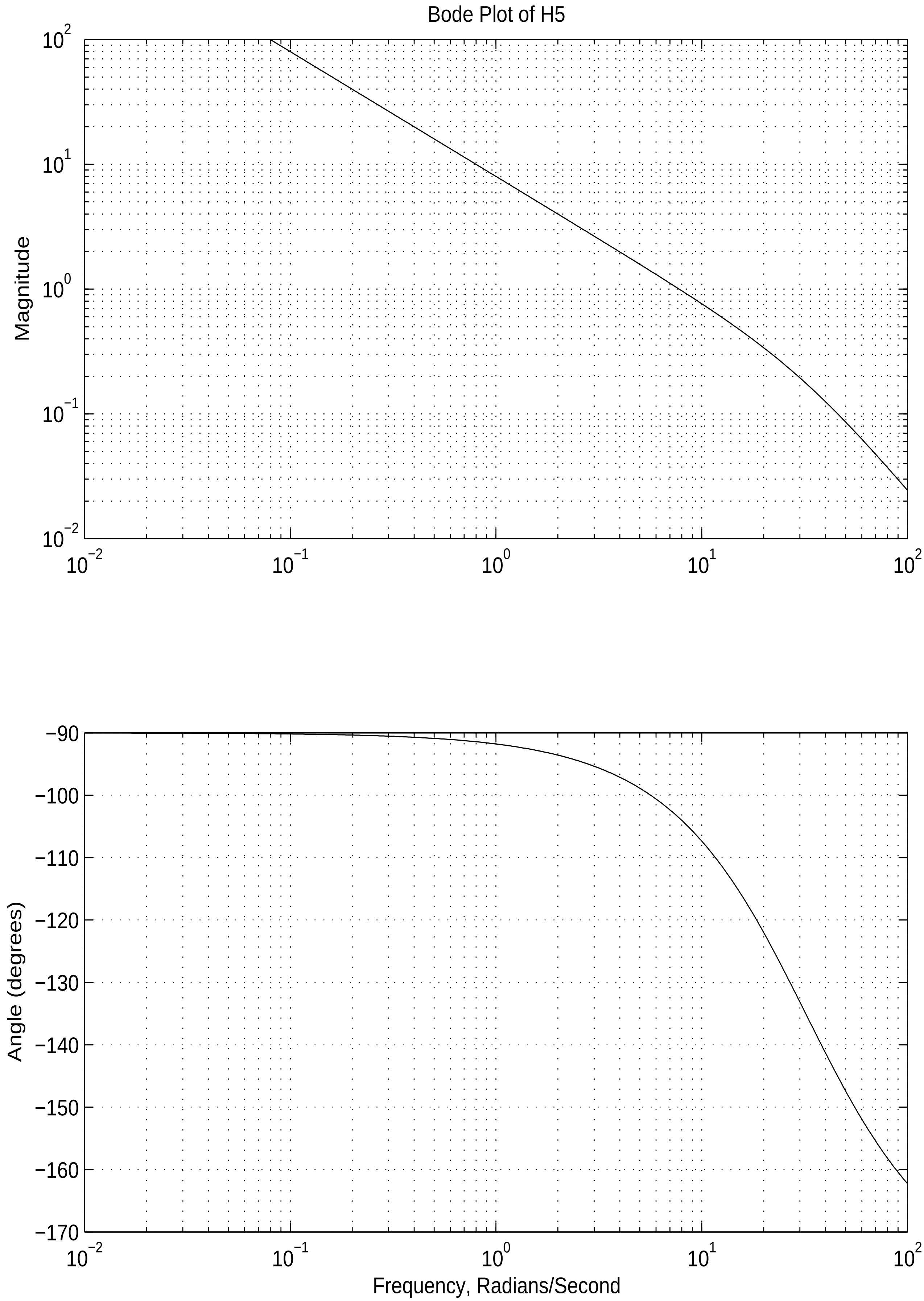

Bode Plot of H2
Magnitude
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
Angle (degrees)
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
Frequency, Radians/Second

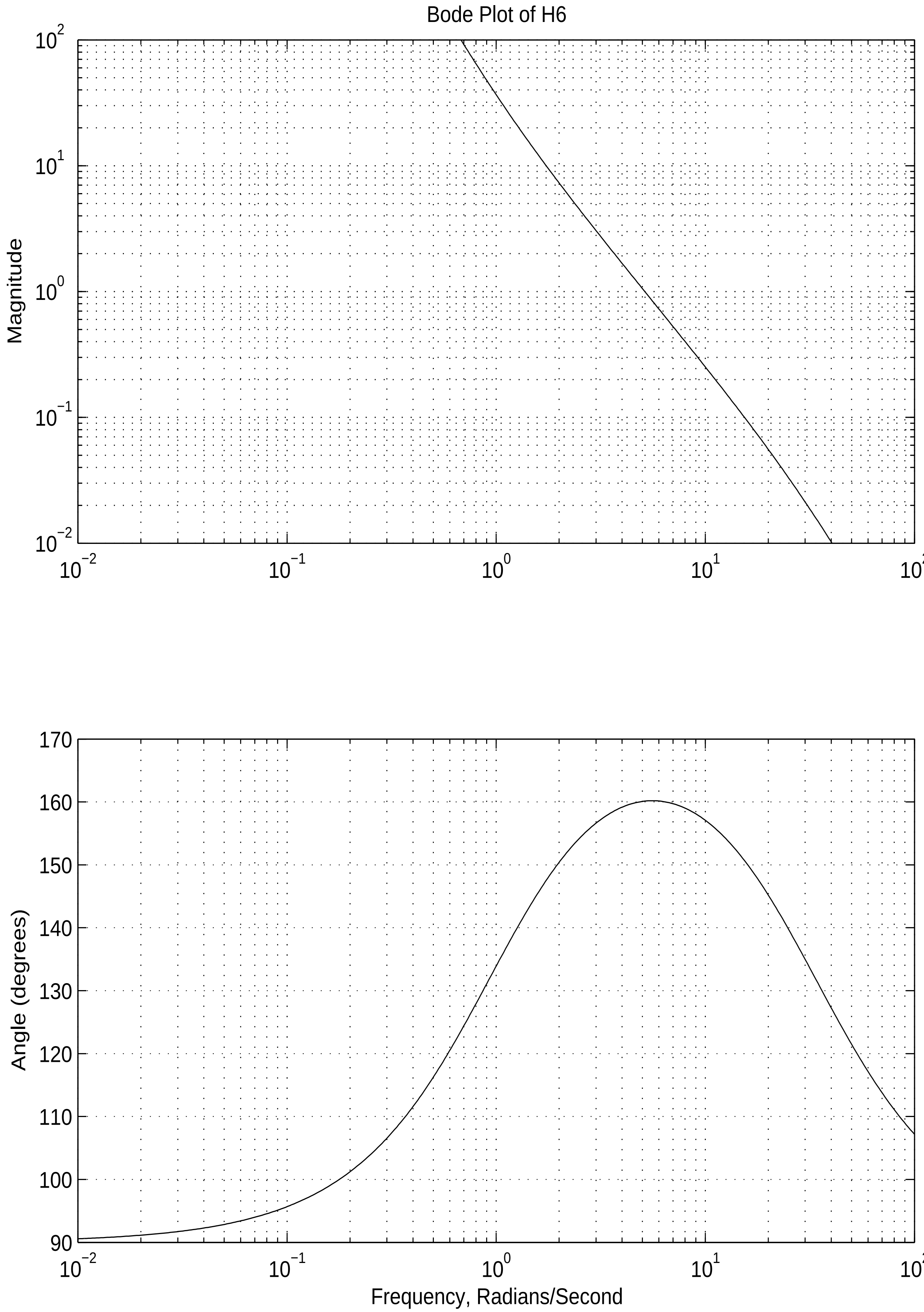


Bode Plot of H3
Magnitude
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
Angle (degrees)
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
−90
−100
−110
−120
−130
−140
−150
−160
−170
−180
Frequency, Radians/Second



Bode Plot of H4
Magnitude
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2}
Angle (degrees)
240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80
Frequency, Radians/Second


Bode Plot of H5
Magnitude
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2}
Angle (degrees)
−90
−100
−110
−120
−130
−140
−150
−160
−170
10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2}
Frequency, Radians/Second


Bode Plot of H6
Magnitude
10^2
10^1
10^0
10^−1
10^−2
10^−2
10^−1
10^0
10^1
10^2
Angle (degrees)
170
160
150
140
130
120
110
100
90
Frequency, Radians/Second