VI.13

(a) Inner loop lead design

Want: CLBW = 3 rad/s $\Rightarrow$ $\omega_c = 3$ rad/s

PM = 25 deg

From OL freq response (plant only), PM = 0 deg

$\Rightarrow \phi_{max} = 25$ deg

$\frac{1}{\alpha} = 2.46$

$z = \omega_c \sqrt{\alpha} = 1.91$ rad/s

$p = \frac{z}{\alpha} = 4.71$ rad/s

$K = -73,508$

$$D_{inner}(s) = -73,508 \; \frac{\frac{s}{1.91} + 1}{\frac{s}{4.71} + 1}$$

(see plot)

negative sign due to "−" in G(s)

$K_{DC} = 0.789$

(b) $$G_{outer}(s) = -K_{DC} \frac{Ls^2 + g}{s^2}$$

Want CLBW = 0.5 rad/s $\Rightarrow$ $\omega_c = 0.5$ rad/s

$\zeta = 0.4$ PM = 40 deg

From OL freq resp (plant only), PM = 0 deg

$\Rightarrow \phi_{max} = 40$ deg

$\frac{1}{\alpha} = 4.60$

$z = \omega_c \sqrt{\alpha} = 0.233$ rad/s

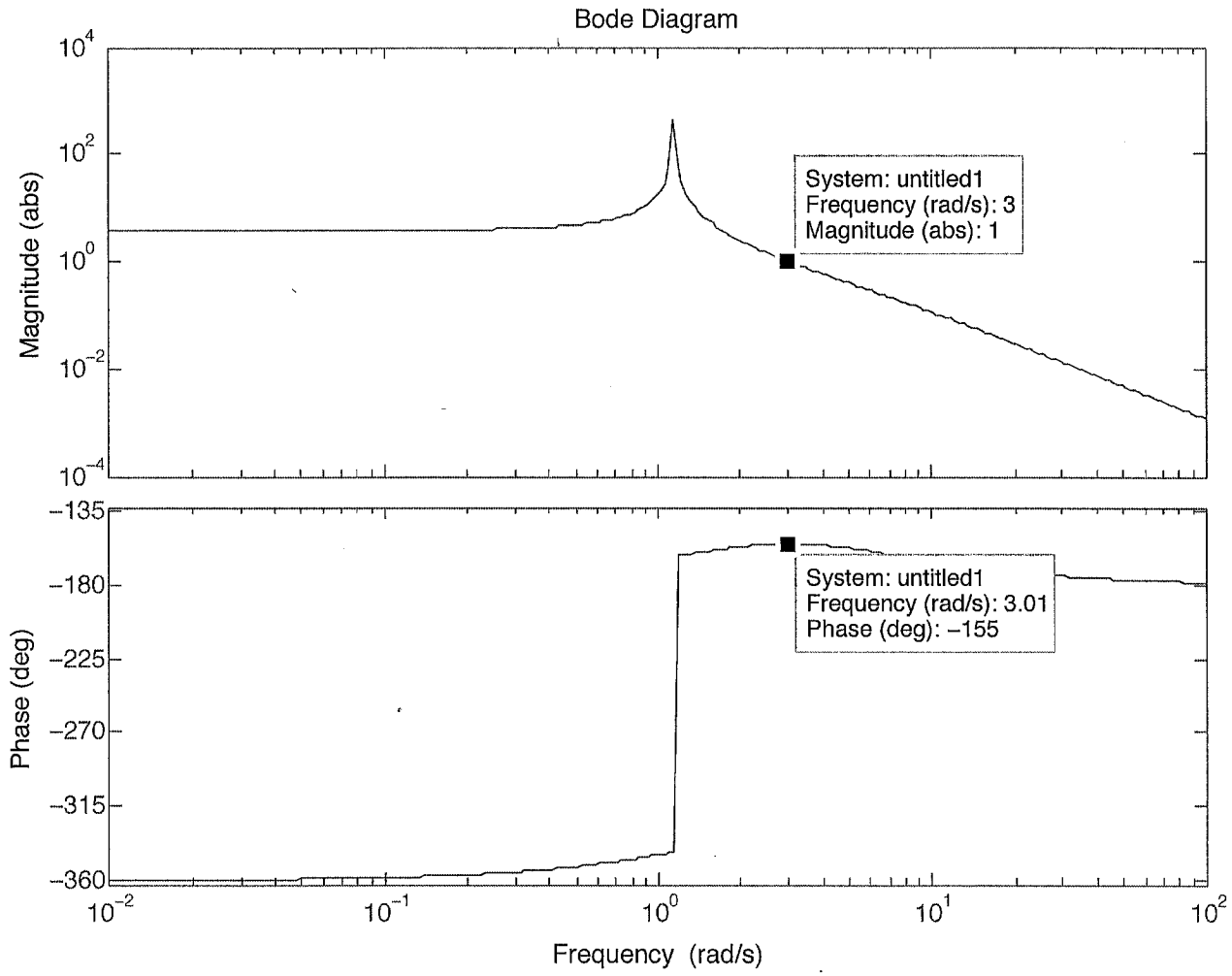
$p = \frac{z}{\alpha} = 1.072$ rad/s

$K = -0.0203$

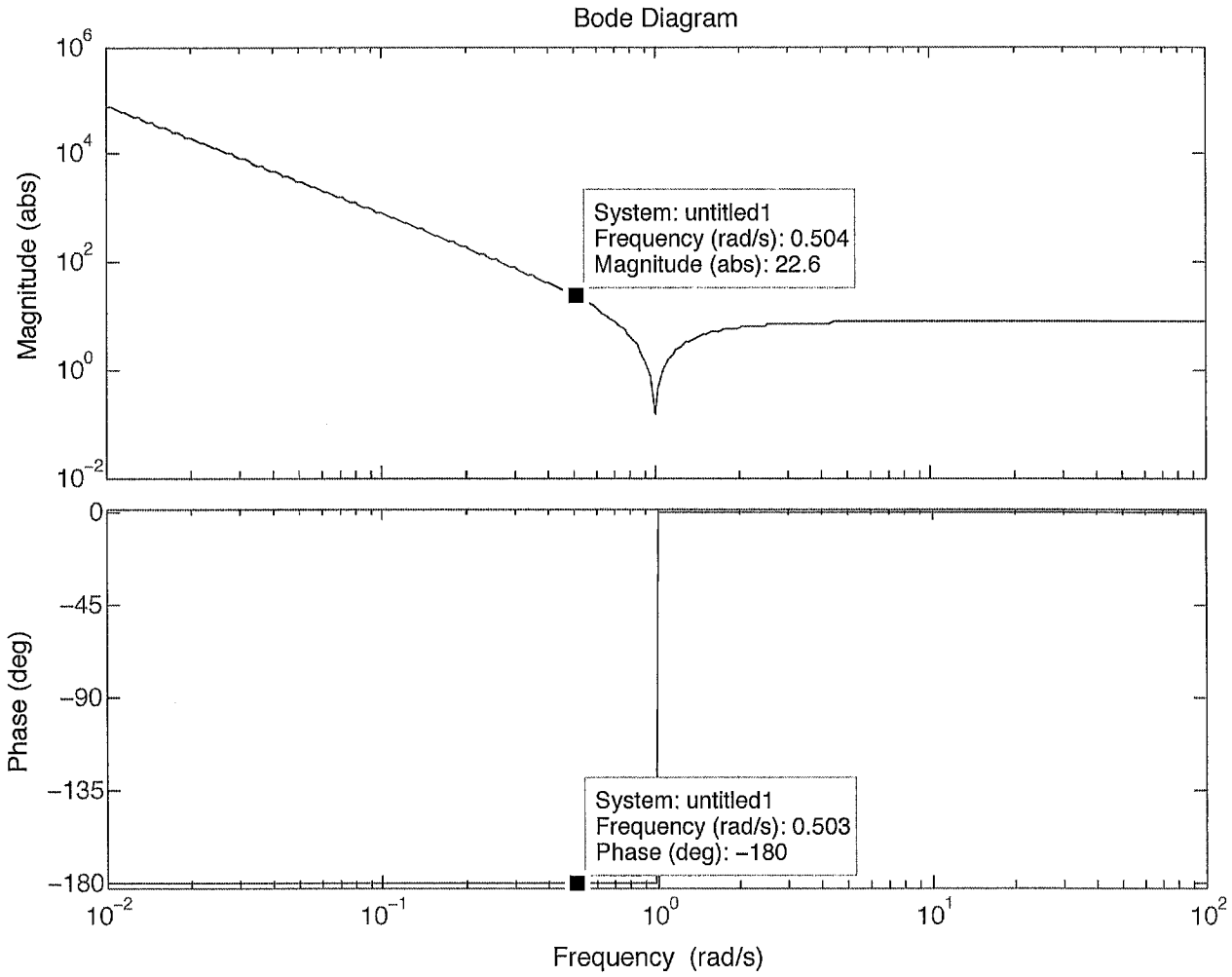
$$D_{outer}(s) = -0.0203 \; \frac{\frac{s}{0.233} + 1}{\frac{s}{1.072} + 1}$$

(see plot)

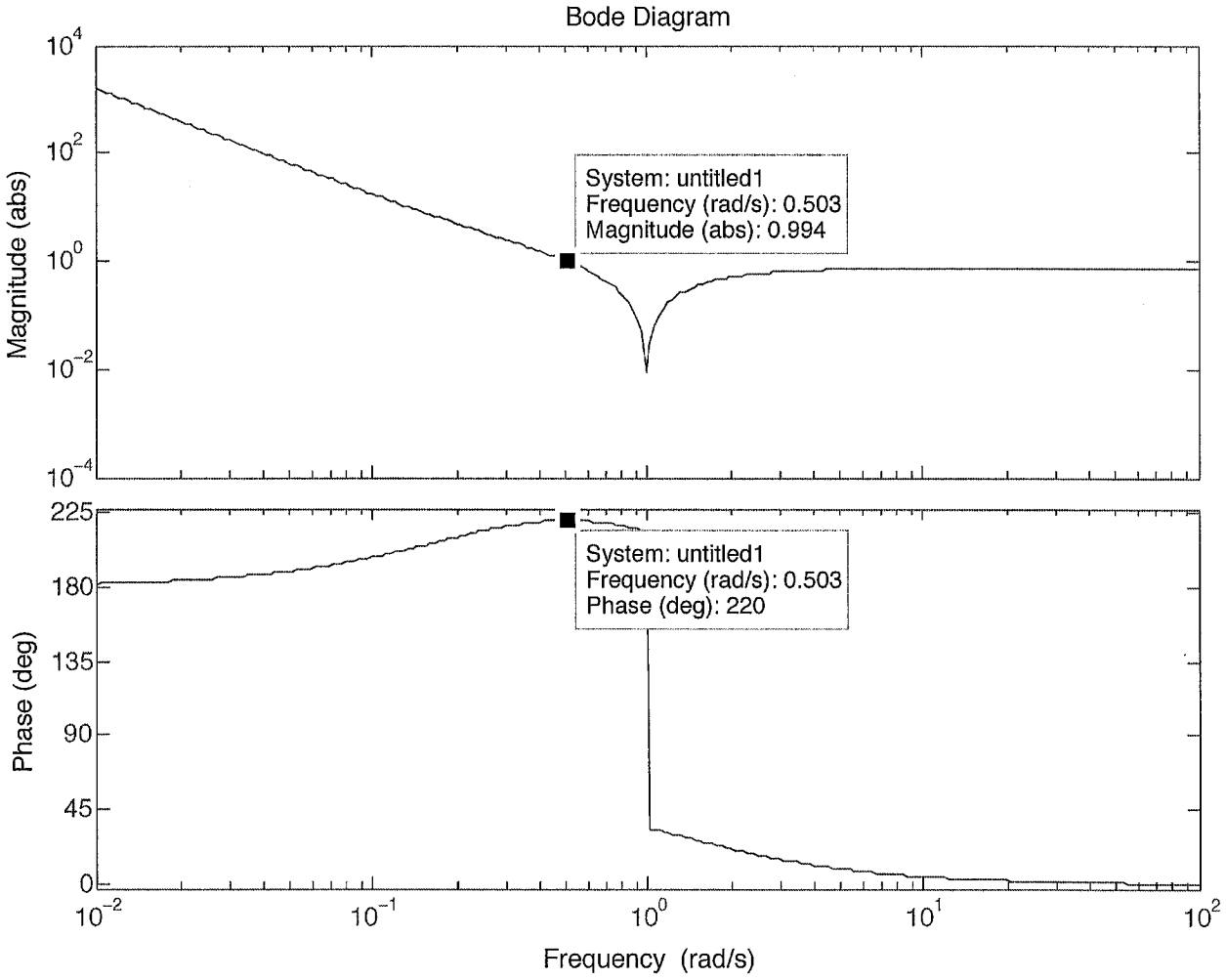
VI.13 (a)


Bode Diagram
Magnitude (abs)
System: untitled1
Frequency (rad/s): 3
Magnitude (abs): 1
Phase (deg)
System: untitled1
Frequency (rad/s): 3.01
Phase (deg): −155
Frequency (rad/s)

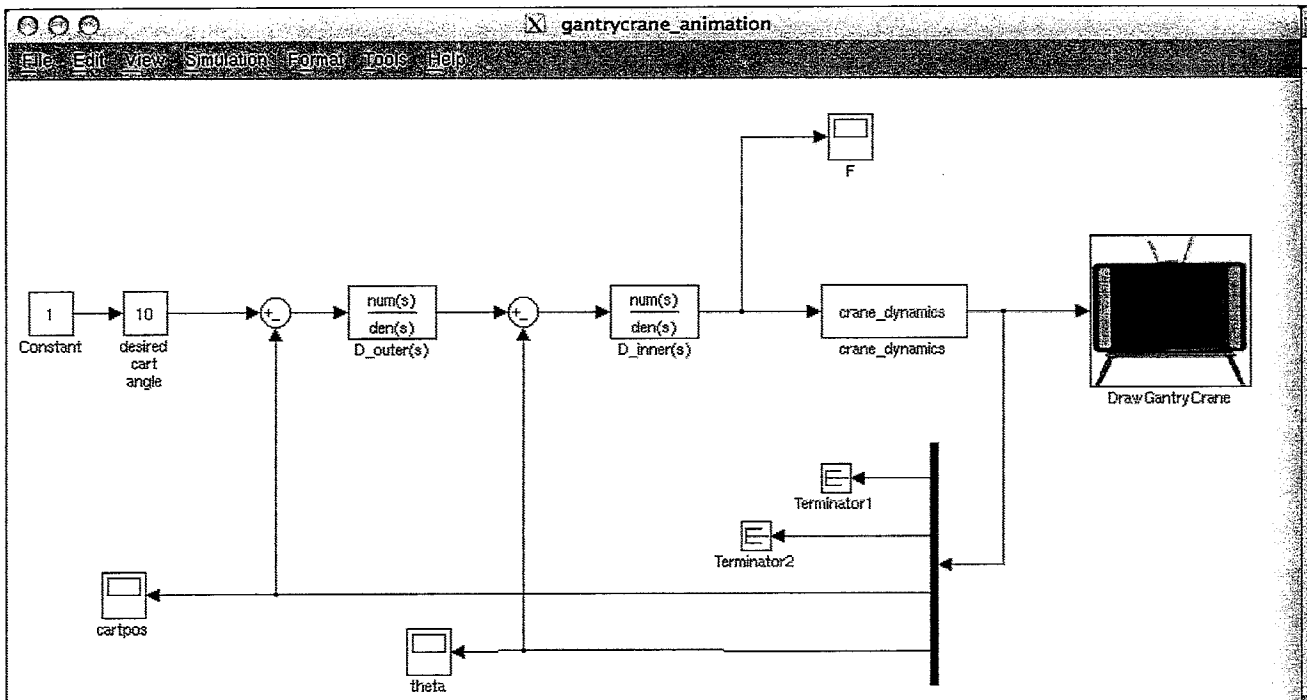
VI.13 (b)

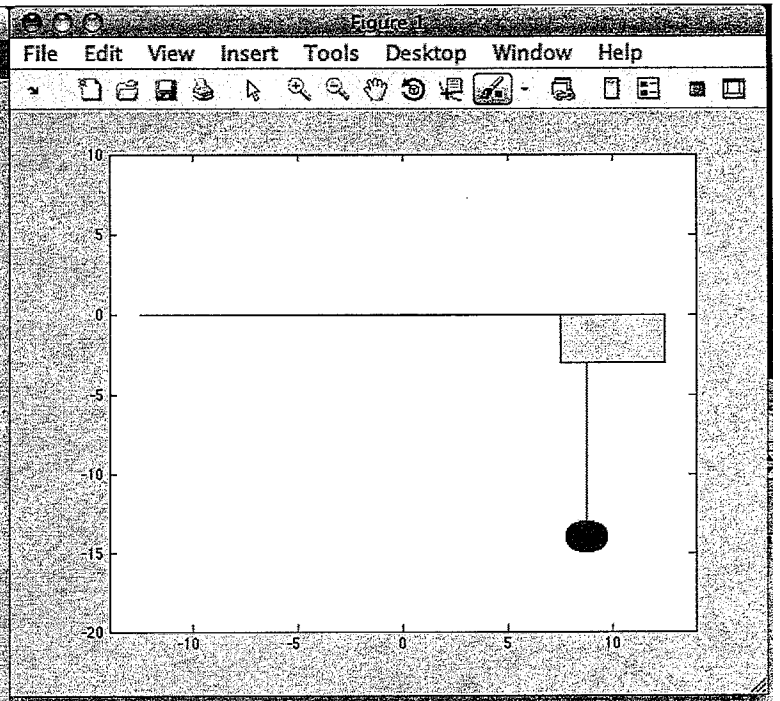

Bode Diagram
Magnitude (abs)
10^6
10^4
10^2
10^0
10^{-2}
System: untitled1
Frequency (rad/s): 0.504
Magnitude (abs): 22.6
Phase (deg)
0
-45
-90
-135
-180
System: untitled1
Frequency (rad/s): 0.503
Phase (deg): -180
10^{-2}
10^{-1}
10^0
10^1
10^2
Frequency (rad/s)

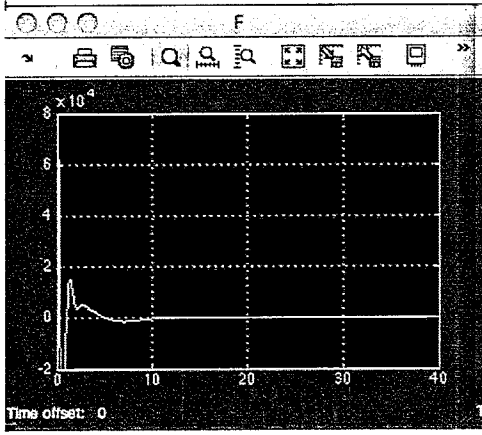
V1.13 (b)

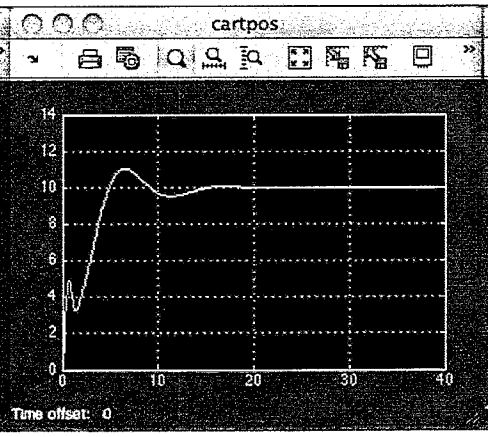

Bode Diagram
Magnitude (abs)
10^4
10^2
10^0
10^{-2}
10^{-4}
System: untitled1
Frequency (rad/s): 0.503
Magnitude (abs): 0.994
Phase (deg)
225
180
135
90
45
0
System: untitled1
Frequency (rad/s): 0.503
Phase (deg): 220
10^{-2}
10^{-1}
10^0
10^1
10^2
Frequency (rad/s)

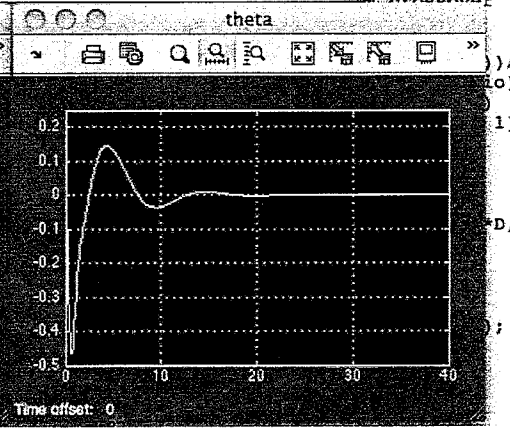
V1.13 (c)












```
))/(1-sin(phase));
lo)
1]);
D,'v'}
);
```