In [45]:
```
from scipy import signal
import numpy as np
import matplotlib.pyplot as plt
import matplotlib.patches as patches
import control
```

In [46]:
```
#5.2

S = [1, .97, .87, .71, .5, .26, 0]
plt.title('Pole-Zero Plot of the System')
plt.xlabel('Real Part')
plt.ylabel('Imaginary Part')
plt.axhline(0, color='black', lw=1, ls='--')
plt.axvline(0, color='black', lw=1, ls='--')

for s in S:

    num = [10]

    den = [1, 6.32*s, 10.0]

    sys = control.tf(num, den)
    control.pole_zero_plot(sys, plot=True, label='s = ' + str(s))

plt.grid()
plt.axis('on')
plt.show()


fig, ax = plt.subplots()

for s in S:

    num = [10]

    den = [1, 6.32*s, 10.0]

    sys = control.tf(num, den)
    control.pole_zero_plot(sys, plot=True, label='s = ' + str(s))

circle = plt.Circle((0, 0), np.sqrt(10), color='r', fill=False, linestyle='dotted')
ax.add_patch(circle)
plt.title('Pole-Zero Plot of the System')
plt.xlabel('Real Part')
plt.ylabel('Imaginary Part')
plt.axhline(0, color='black', lw=1, ls='--')
plt.axvline(0, color='black', lw=1, ls='--')
plt.grid()
plt.show()
```

```
c:\Users\Frankie\anaconda3\envs\EE447\Lib\site-packages\control\pzmap.py:318: Future
Warning: pole_zero_plot() return value of poles, zeros is deprecated; use pole_zero_
map()
  warnings.warn(
c:\Users\Frankie\anaconda3\envs\EE447\Lib\site-packages\control\pzmap.py:318: Future
Warning: pole_zero_plot() return value of poles, zeros is deprecated; use pole_zero_
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c:\Users\Frankie\anaconda3\envs\EE447\Lib\site-packages\control\pzmap.py:318: Future
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c:\Users\Frankie\anaconda3\envs\EE447\Lib\site-packages\control\pzmap.py:318: Future
Warning: pole_zero_plot() return value of poles, zeros is deprecated; use pole_zero_
map()
  warnings.warn(
```

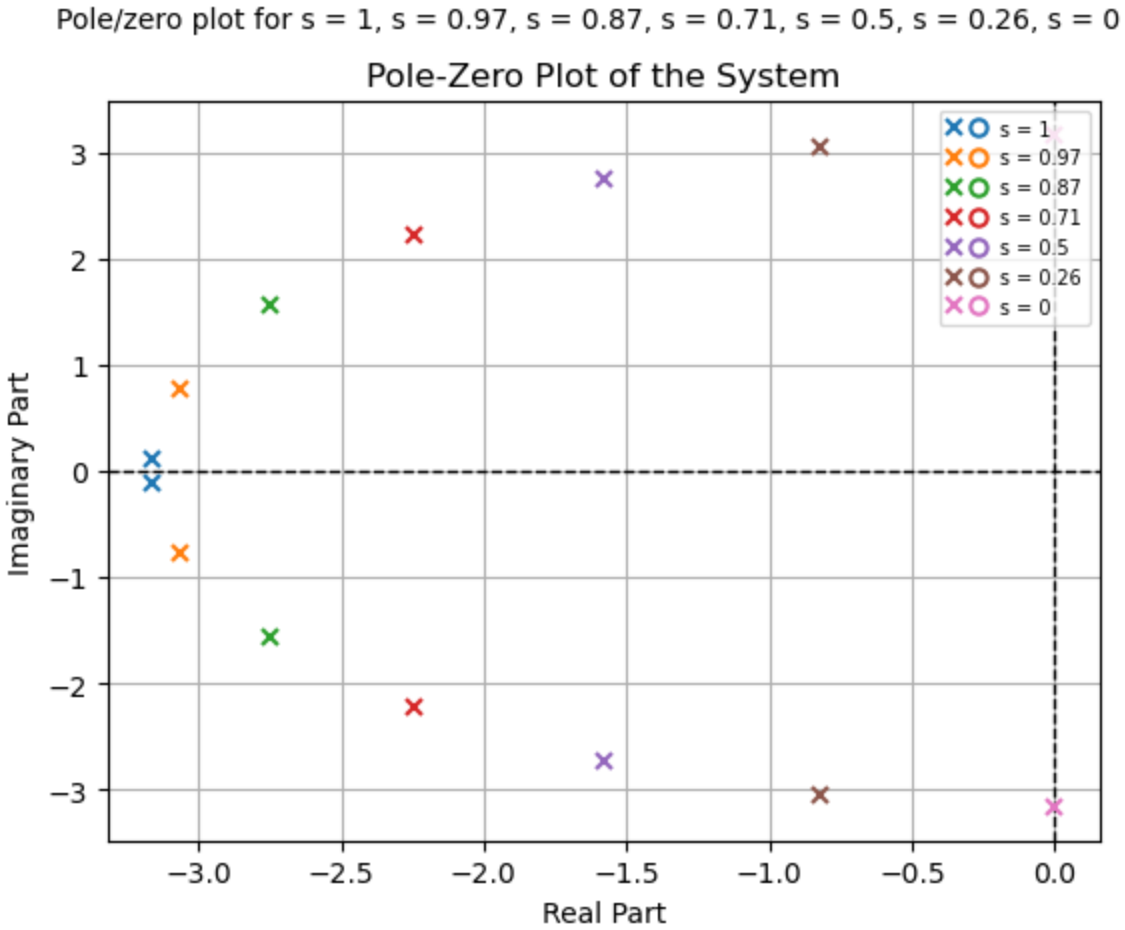
Pole/zero plot for s = 1, s = 0.97, s = 0.87, s = 0.71, s = 0.5, s = 0.26, s = 0
Pole-Zero Plot of the System
s = 1
s = 0.97
s = 0.87
s = 0.71
s = 0.5
s = 0.26
s = 0
Imaginary Part
Real Part
3
2
1
0
−1
−2
−3
−3.0
−2.5
−2.0
−1.5
−1.0
−0.5
0.0

```
c:\Users\Frankie\anaconda3\envs\EE447\Lib\site-packages\control\pzmap.py:318: Future
Warning: pole_zero_plot() return value of poles, zeros is deprecated; use pole_zero_
map()
  warnings.warn(
c:\Users\Frankie\anaconda3\envs\EE447\Lib\site-packages\control\pzmap.py:318: Future
Warning: pole_zero_plot() return value of poles, zeros is deprecated; use pole_zero_
map()
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c:\Users\Frankie\anaconda3\envs\EE447\Lib\site-packages\control\pzmap.py:318: Future
Warning: pole_zero_plot() return value of poles, zeros is deprecated; use pole_zero_
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c:\Users\Frankie\anaconda3\envs\EE447\Lib\site-packages\control\pzmap.py:318: Future
Warning: pole_zero_plot() return value of poles, zeros is deprecated; use pole_zero_
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  warnings.warn(
c:\Users\Frankie\anaconda3\envs\EE447\Lib\site-packages\control\pzmap.py:318: Future
Warning: pole_zero_plot() return value of poles, zeros is deprecated; use pole_zero_
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c:\Users\Frankie\anaconda3\envs\EE447\Lib\site-packages\control\pzmap.py:318: Future
Warning: pole_zero_plot() return value of poles, zeros is deprecated; use pole_zero_
map()
  warnings.warn(
c:\Users\Frankie\anaconda3\envs\EE447\Lib\site-packages\control\pzmap.py:318: Future
Warning: pole_zero_plot() return value of poles, zeros is deprecated; use pole_zero_
map()
  warnings.warn(
```
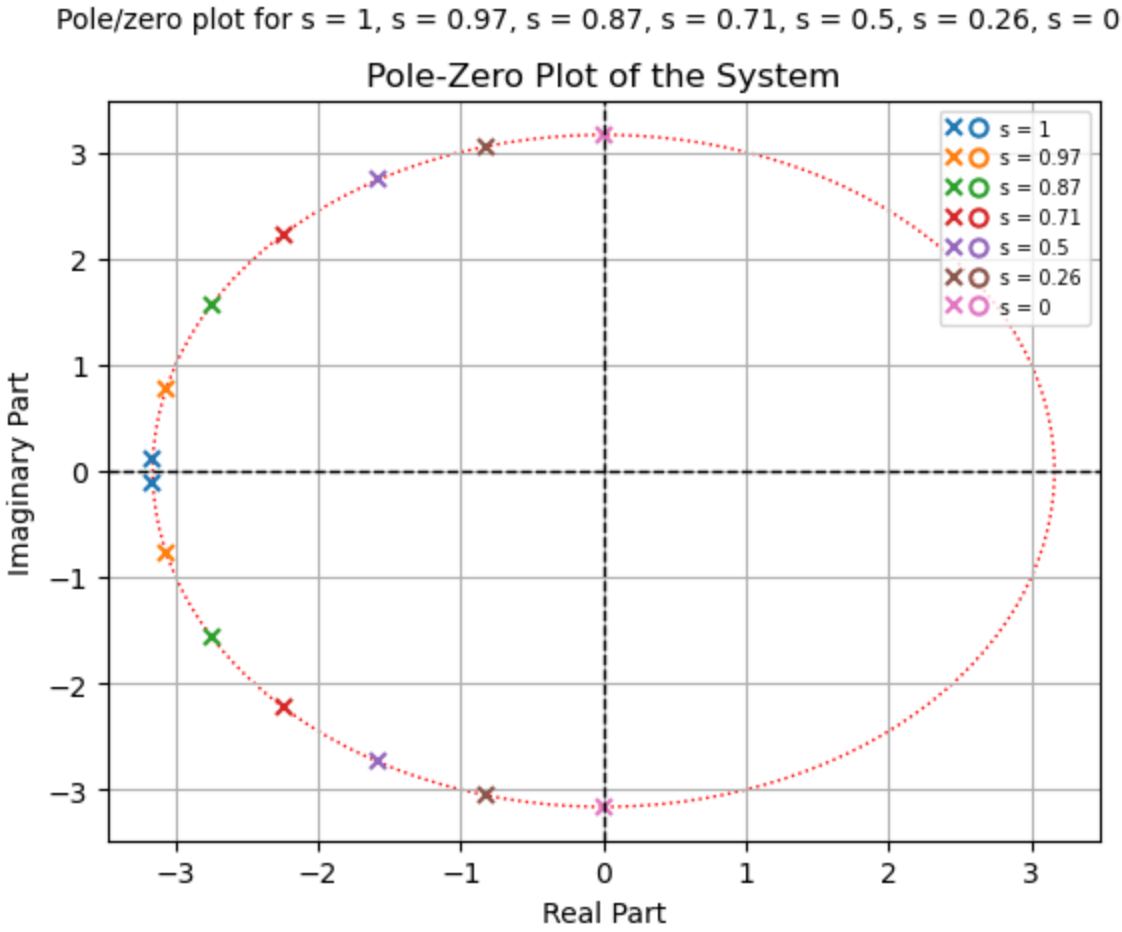
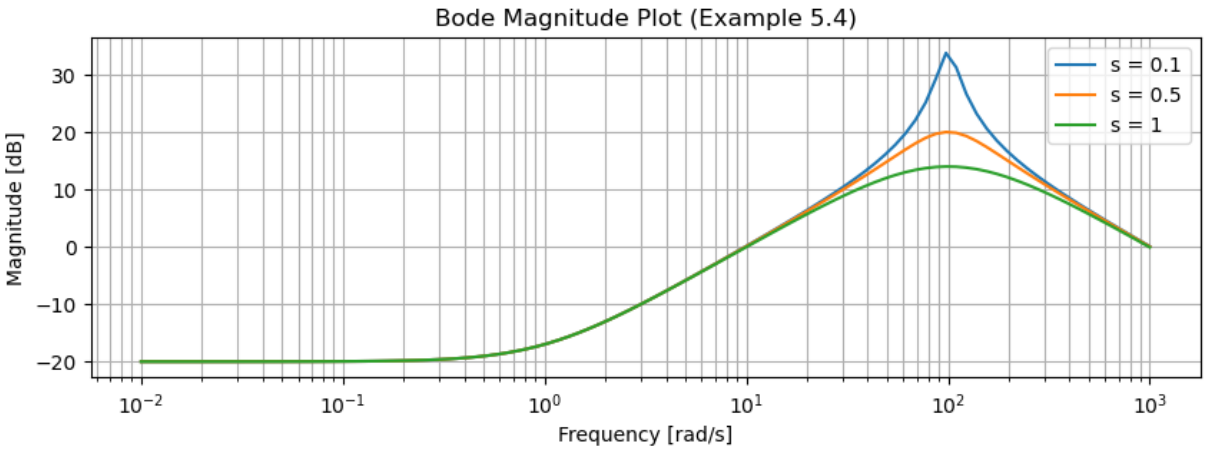
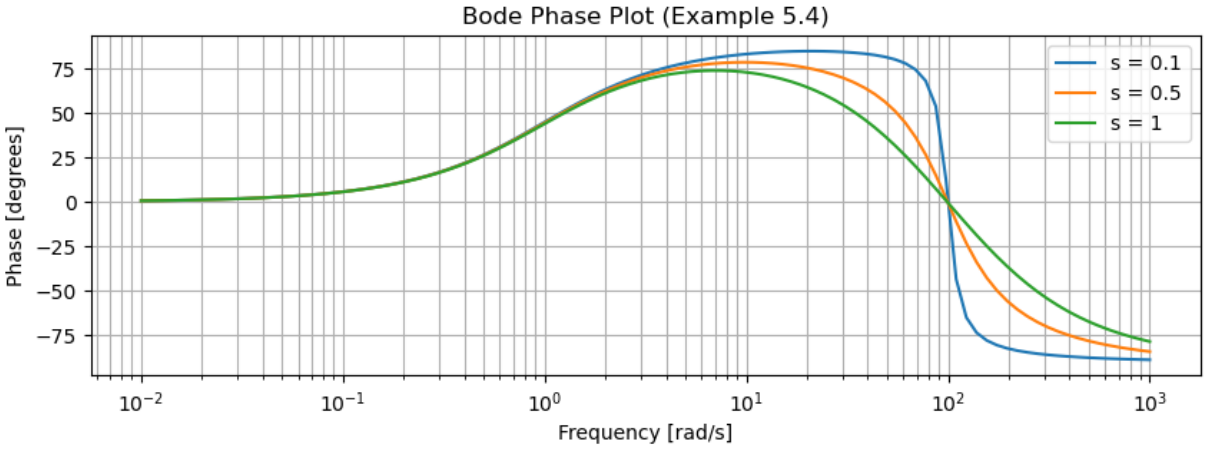



In [ ]:
```
#5.3/5.4

# totally want to make it so that the user can select the plot they want to see,
# but i can only submit ipynb files as a pdf so i remove the if statement and just


sys = signal.TransferFunction([31.6, 3160], [1, 1003.16, 3160])
w, mag, phase = signal.bode(sys)
plt.figure()
plt.semilogx(w, mag)    # Bode magnitude plot
plt.title('Bode Magnitude Plot (Example 5.3)')
plt.xlabel('Frequency [rad/s]')
plt.ylabel('Magnitude [dB]')
plt.grid(which='both', axis='both')
plt.figure()
plt.semilogx(w, phase)  # Bode phase plot
plt.title('Bode Phase Plot (Example 5.3)')
plt.xlabel('Frequency [rad/s]')
plt.ylabel('Phase [degrees]')
plt.grid(which='both', axis='both')
plt.show()


S = [0.1, 0.5, 1]
wo = 1e2
fig1, ax = plt.subplots(2, 1, figsize=(10, 8))
for s in S:
```

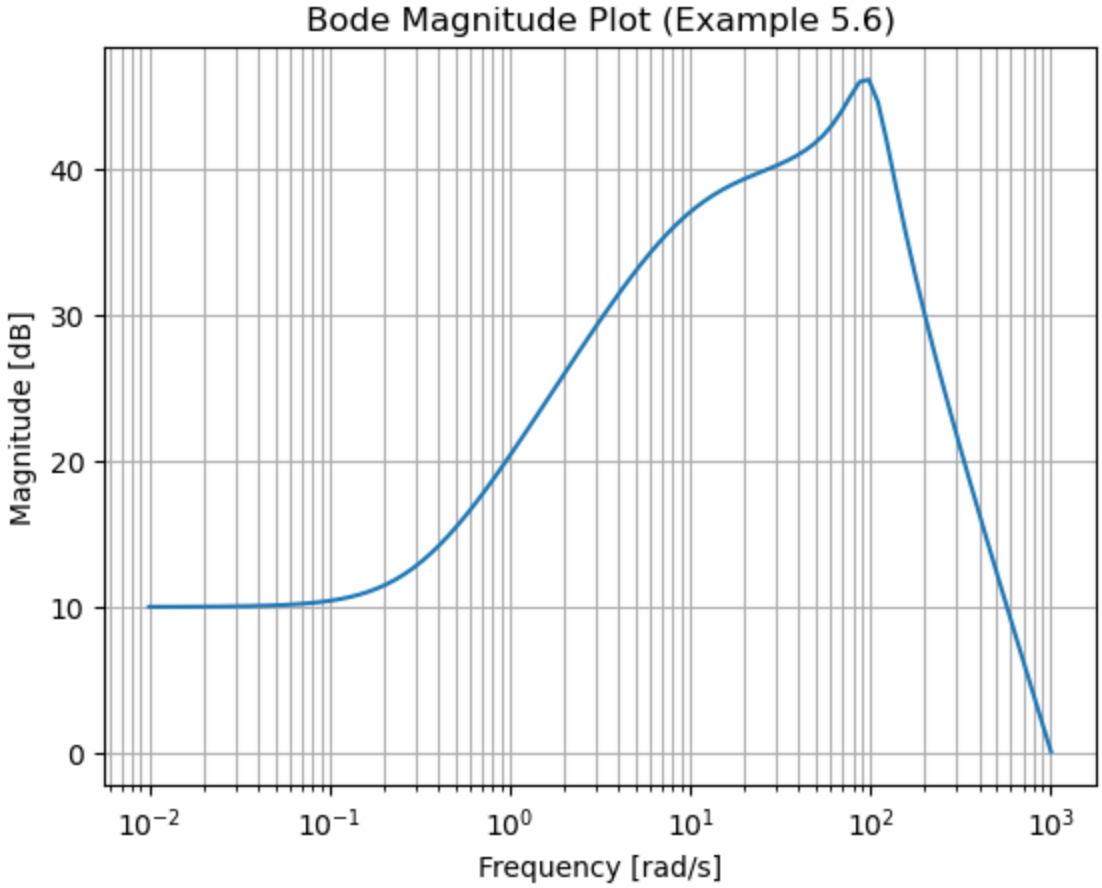
```
    a = 2 * s * wo
    b = wo**2
    sys = signal.TransferFunction([1000, 1000], [1, a, b])
    w, mag, phase = signal.bode(sys)
    ax[0].semilogx(w, mag)    # Bode magnitude plot
    ax[1].semilogx(w, phase)  # Bode phase plot
ax[0].title.set_text('Bode Magnitude Plot (Example 5.4)')
ax[0].set_xlabel('Frequency [rad/s]')
ax[0].set_ylabel('Magnitude [dB]')
ax[0].grid(which='both', axis='both')
ax[1].title.set_text('Bode Phase Plot (Example 5.4)')
ax[1].set_xlabel('Frequency [rad/s]')
ax[1].set_ylabel('Phase [degrees]')
ax[1].grid(which='both', axis='both')
plt.subplots_adjust(wspace=0.4, hspace=0.6)
ax[0].legend(['s = ' + str(s) for s in S], loc='best')
ax[1].legend(['s = ' + str(s) for s in S], loc='best')
plt.show()
```

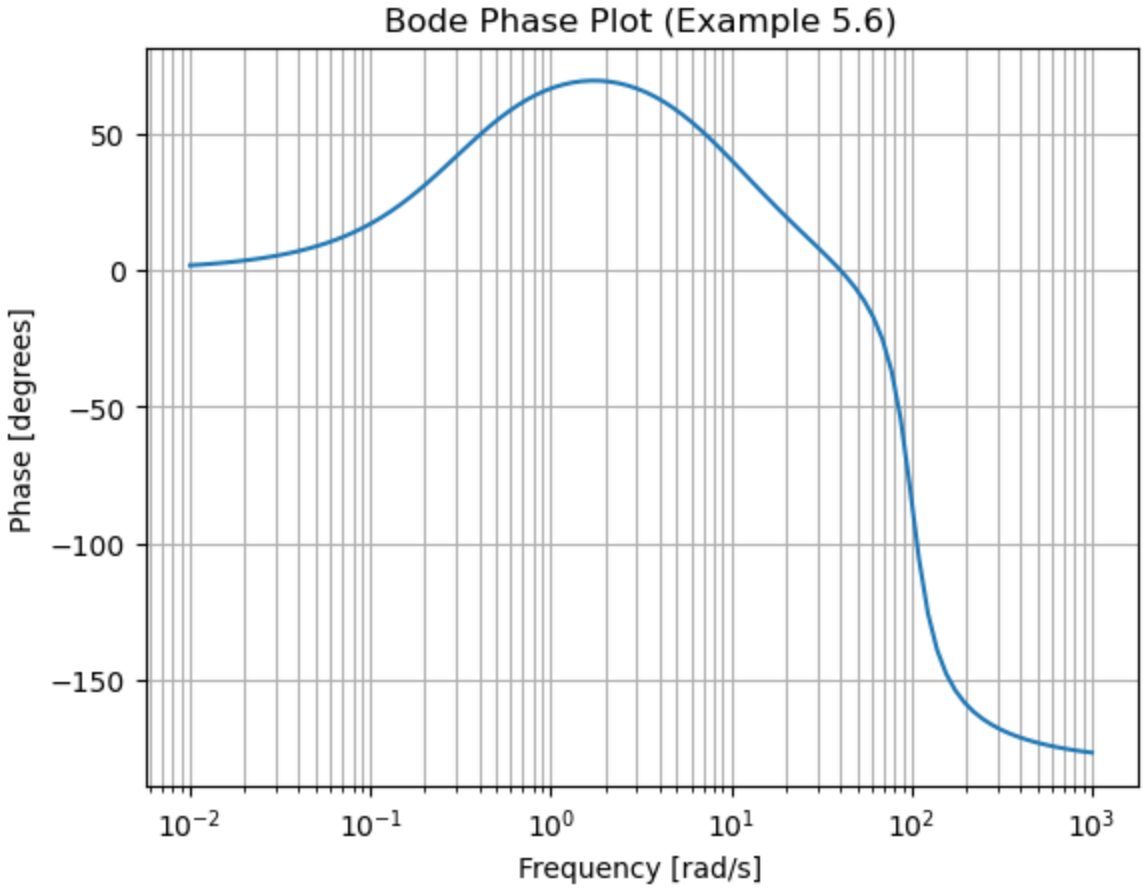




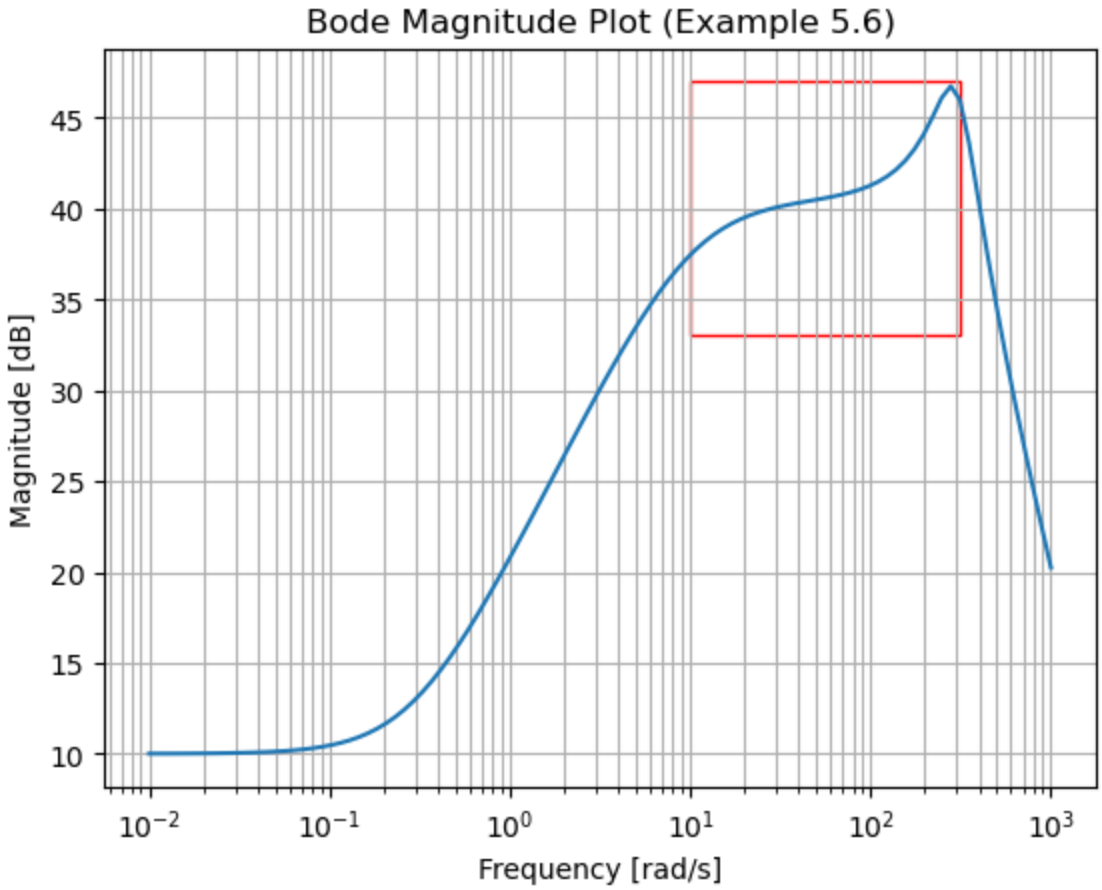
In [57]:
```
#5.6
rect = patches.Rectangle((10, 33), 306, 14, linewidth=1, edgecolor='r', facecolor='

sys = signal.TransferFunction([1000000, 316227.8], [1, 60, 10500, 1e5])
w, mag, phase = signal.bode(sys)
plt.figure()
plt.semilogx(w, mag)    # Bode magnitude plot
```

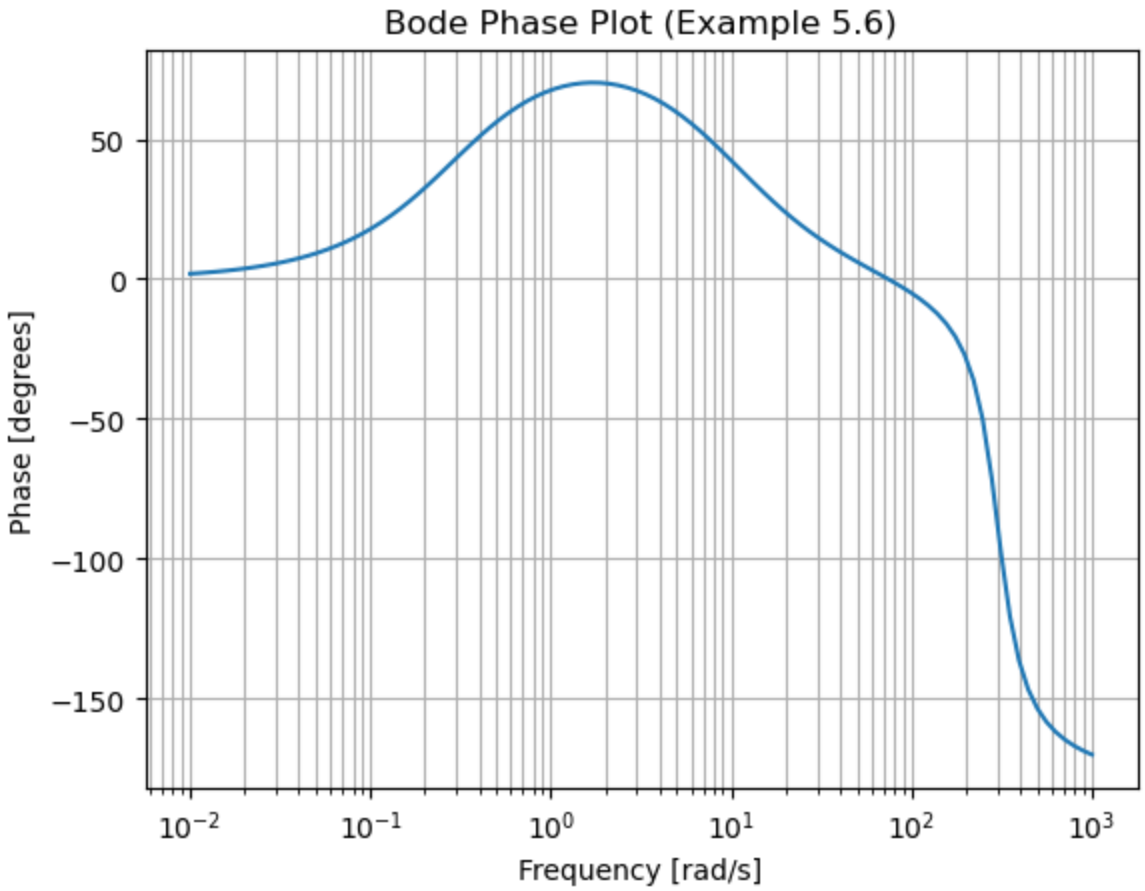
```
plt.title('Bode Magnitude Plot (Example 5.6)')
plt.xlabel('Frequency [rad/s]')
plt.ylabel('Magnitude [dB]')
plt.grid(which='both', axis='both')
plt.figure()
plt.semilogx(w, phase)  # Bode phase plot
plt.title('Bode Phase Plot (Example 5.6)')
plt.xlabel('Frequency [rad/s]')
plt.ylabel('Phase [degrees]')
plt.grid(which='both', axis='both')
plt.show()

#modified example 5.6

a = 9486833

sys = signal.TransferFunction([a, a * .3], [1, 160, 91500, 900000])
w, mag, phase = signal.bode(sys)
plt.figure()
plt.semilogx(w, mag)    # Bode magnitude plot
print(mag.max())
plt.title('Bode Magnitude Plot (Example 5.6)')
plt.xlabel('Frequency [rad/s]')
plt.ylabel('Magnitude [dB]')
plt.grid(which='both', axis='both')

plt.gca().add_patch(rect)
plt.figure()
plt.semilogx(w, phase)  # Bode phase plot
plt.title('Bode Phase Plot (Example 5.6)')
plt.xlabel('Frequency [rad/s]')
plt.ylabel('Phase [degrees]')
plt.grid(which='both', axis='both')


plt.show()
```






```
46.74885550891884
```


Bode Magnitude Plot (Example 5.6)
Magnitude [dB]
45
40
35
30
25
20
15
10
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
Frequency [rad/s]


Bode Phase Plot (Example 5.6)
Phase [degrees]
50
0
−50
−100
−150
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
Frequency [rad/s]