Table of Contents


```
% Benjamin Stutzke
% ENAE432 - 0102
% Homework 8
```

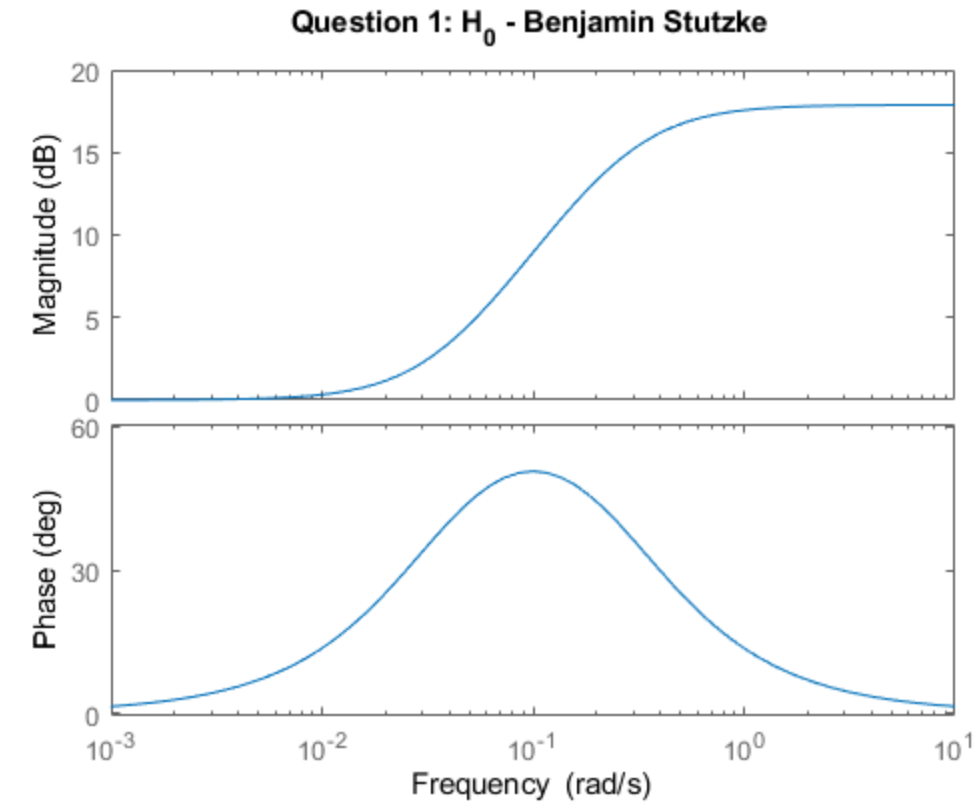
Question 1

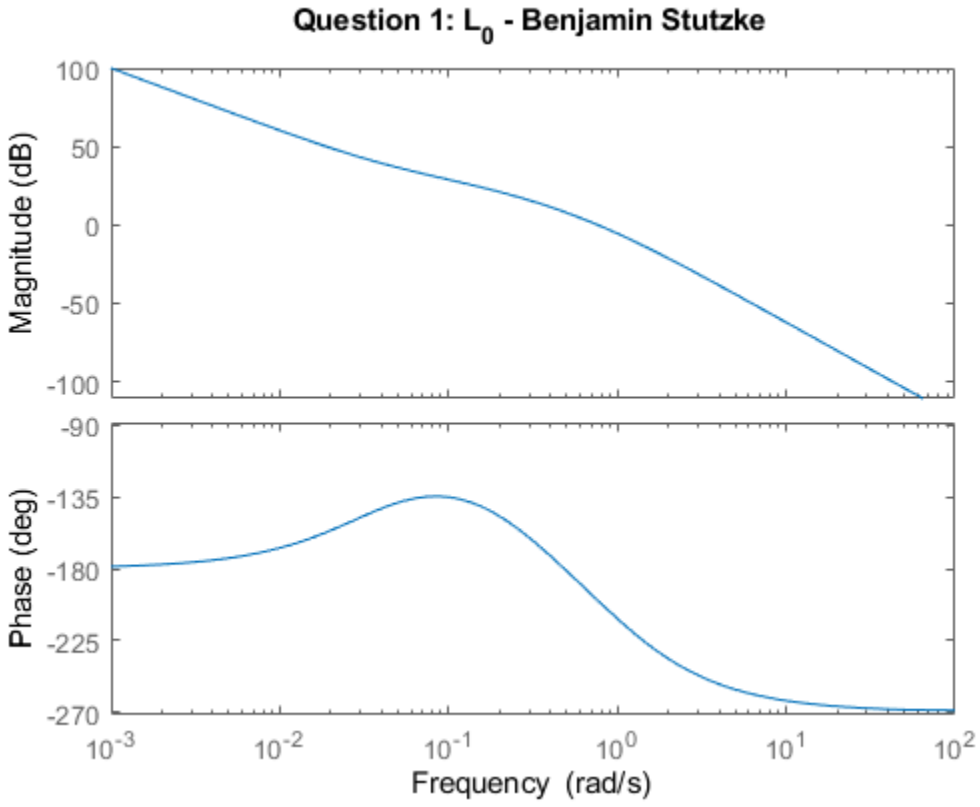
```
s = tf('s');
I = 10;
b = 7.84;
t = 3.57;

% Part A
G = 1/((I*(s^2))*(s+1))
H_0 = (b*t*s + 1)/(t*s + 1)
L_0 = minreal(G * H_0)

figure;
bode(H_0)
title("Question 1: H_0 - Benjamin Stutzke");

figure;
bode(L_0)
title("Question 1: L_0 - Benjamin Stutzke");

% Finding L_0 at omega_des
z = 0.1i;
K = 1/abs(evalfr(L_0, z))

H = H_0 * K
L = minreal(G * H)

figure;
bode(H)
title("Question 1: H - Benjamin Stutzke");

figure;
bode(L)
title("Question 1: L - Benjamin Stutzke");

% Part B
T = minreal(L/(1 + L));
zpk(T)
```

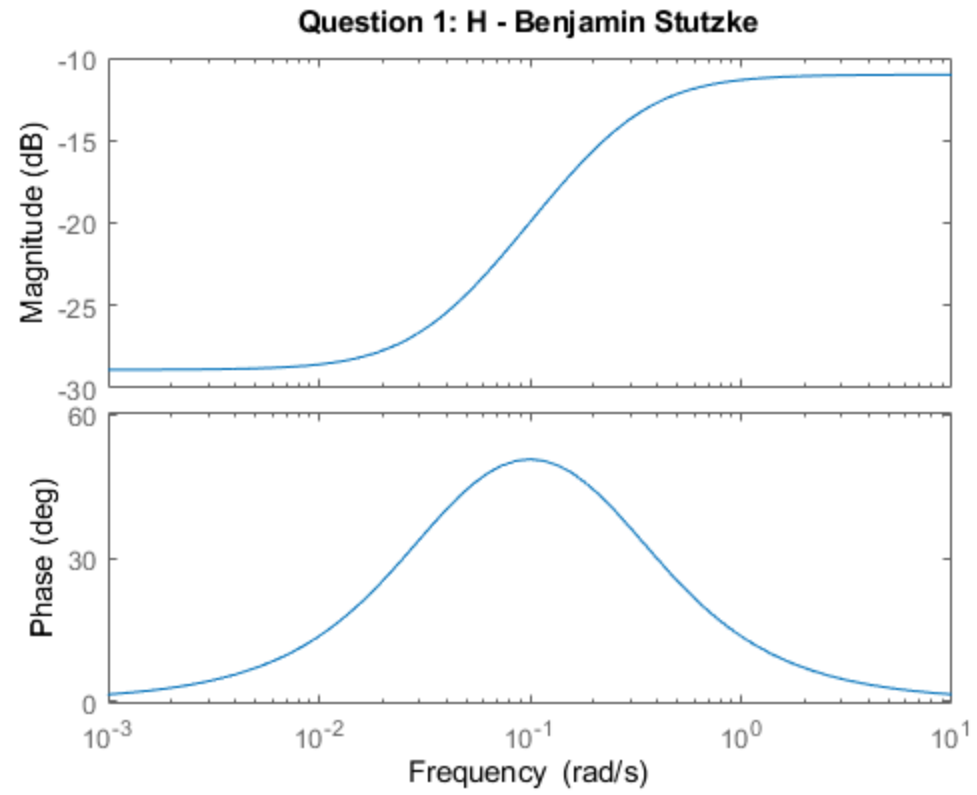
```
% Part C
figure;
step(T)
title("Question 1: Step Response of T - Benjamin Stutzke");

% Part D
I = abs(evalfr(L_0, 0.484i))
L = minreal(L_0/I)
figure;
bode(L)
title("Question 1: L with Minimum I - Benjamin Stutzke");

% Part E
I = 10;
L = minreal(L_0/I);
S = minreal(1/(1+L));

figure;
bode(S);
title("Question 1: Sensitivity Diagram - Benjamin Stutzke");
```

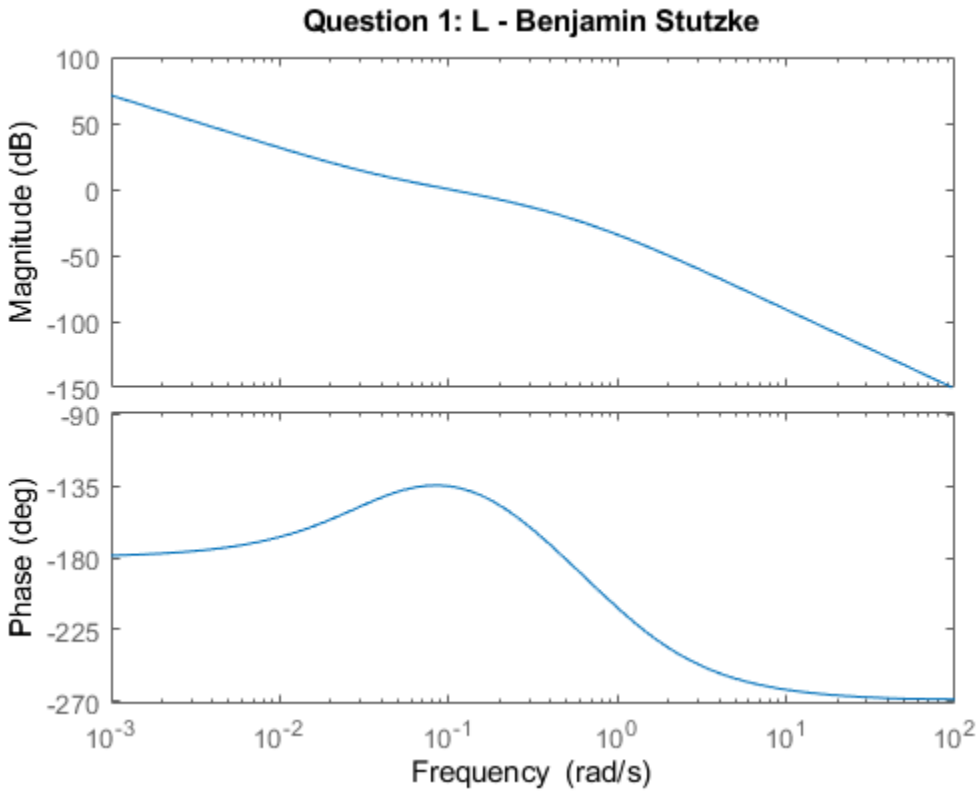
```
G =

         1
  ---------------
  10 s^3 + 10 s^2

Continuous-time transfer function.


H_0 =

  27.99 s + 1
  -----------
  3.57 s + 1

Continuous-time transfer function.


L_0 =

       0.784 s + 0.02801
  --------------------------
  s^4 + 1.28 s^3 + 0.2801 s^2

Continuous-time transfer function.


K =

    0.0359
```

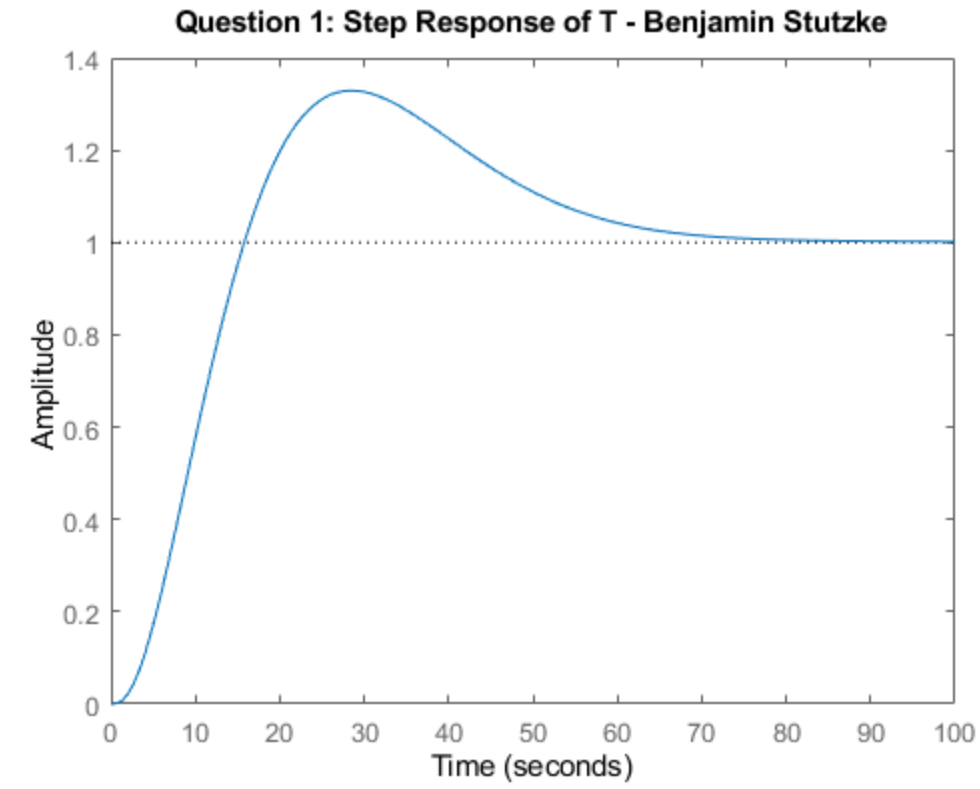
```
H =

  1.005 s + 0.0359
  ----------------
     3.57 s + 1

Continuous-time transfer function.


L =

     0.02815 s + 0.001006
  ---------------------------
  s^4 + 1.28 s^3 + 0.2801 s^2

Continuous-time transfer function.


ans =

                0.028148 (s+0.03573)
  ---------------------------------------------------
  (s+1.035) (s+0.06888) (s^2 + 0.1764s + 0.01411)

Continuous-time zero/pole/gain model.


I =

    2.6144


L =

      0.2999 s + 0.01071
  ---------------------------
  s^4 + 1.28 s^3 + 0.2801 s^2

Continuous-time transfer function.
```

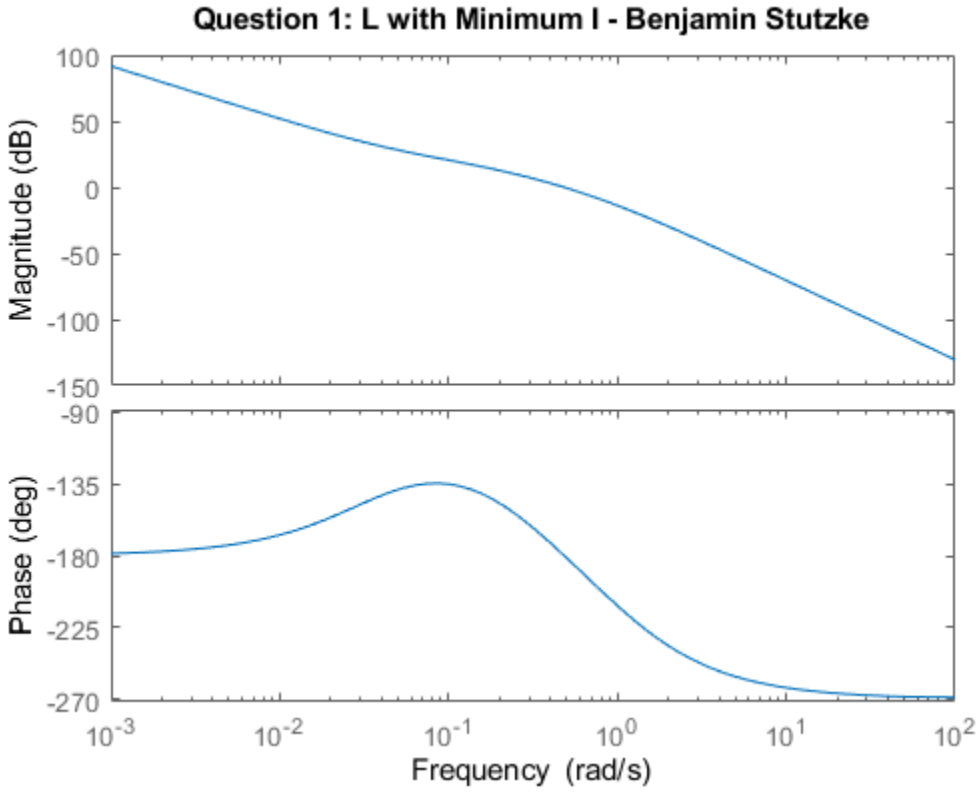

Question 1: H0 - Benjamin Stutzke
Magnitude (dB)
20
15
10
5
0
Phase (deg)
60
30
0
10-3
10-2
10-1
100
101
Frequency (rad/s)

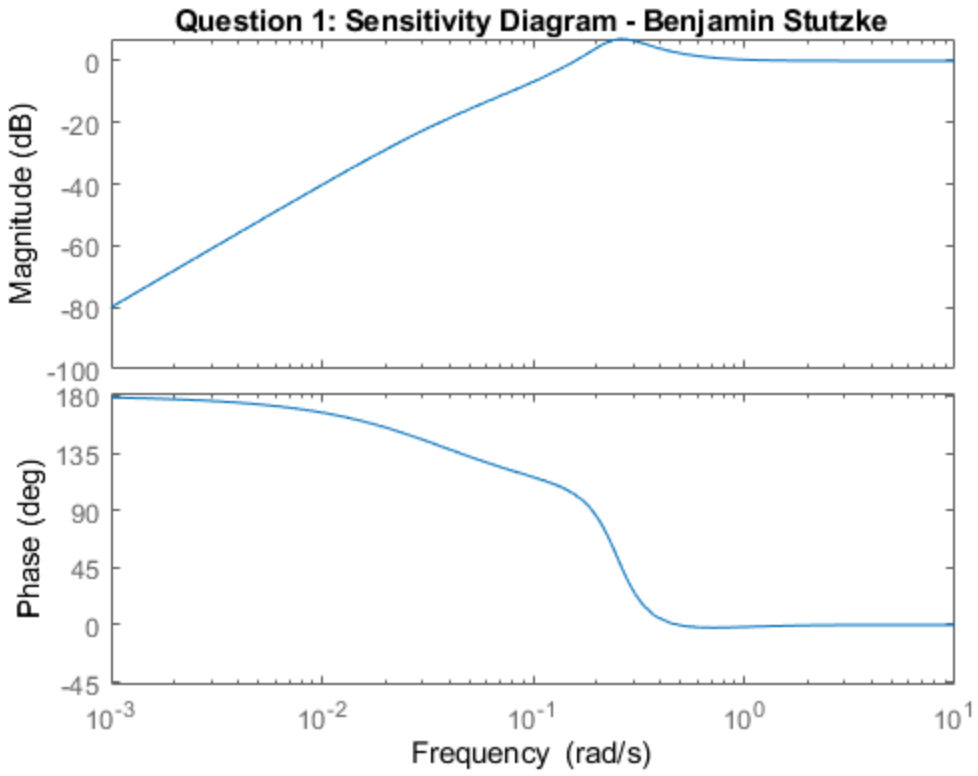

Question 1: L0 - Benjamin Stutzke
Magnitude (dB)
100
50
0
-50
-100
Phase (deg)
-90
-135
-180
-225
-270
10-3
10-2
10-1
100
101
102
Frequency (rad/s)


Question 1: H - Benjamin Stutzke
Magnitude (dB)
-10
-15
-20
-25
-30
Phase (deg)
60
30
0
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
Frequency (rad/s)


Question 1: L - Benjamin Stutzke
Magnitude (dB)
100
50
0
-50
-100
-150
Phase (deg)
-90
-135
-180
-225
-270
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
Frequency (rad/s)


Question 1: Step Response of T - Benjamin Stutzke
Amplitude
Time (seconds)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
10
20
30
40
50
60
70
80
90
100


Question 1: L with Minimum I - Benjamin Stutzke
Magnitude (dB)
Phase (deg)
Frequency (rad/s)
100
50
0
-50
-100
-150
-90
-135
-180
-225
-270
10^-3
10^-2
10^-1
10^0
10^1
10^2



Question 2

Part B

```
s = tf('s');
I = 10;

g_des = 45; % degrees
o_des = 1; % rad/s

G = 1/((I*(s^2))*(s+1))
angle_G = angle(evalfr(G, o_des*sqrt(-1)))
phi_req = g_des - 180 - rad2deg(angle_G)
phi_req = 360 + phi_req
phi_req = deg2rad(phi_req/2)

b = (1+sin(phi_req))/(1-sin(phi_req))
t = 1/(o_des*sqrt(b))

H_10 = (b*t*s + 1)/(t*s + 1)
H_0 = minreal(H_10 * H_10)
L_0 = minreal(G * H_0)

K = 1/abs(evalfr(L_0, o_des*sqrt(-1)))

H = H_0 * K;
```

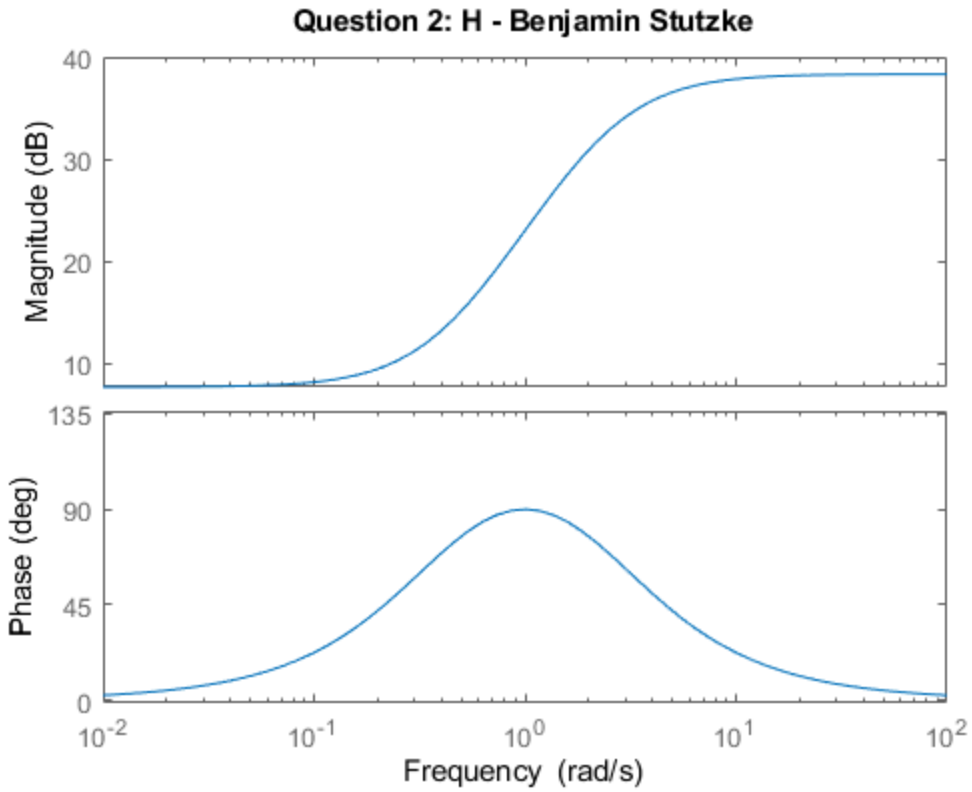
```
L = minreal(G*H);
zpk(L)

figure;
bode(H);
title("Question 2: H - Benjamin Stutzke");

figure;
bode(L)
title("Question 2: L - Benjamin Stutzke");

% Finding poles of T
T = minreal(L/(1 + L));
zpk(T)
roots([1 .6633 .1658])
roots([1 1.248 2.177])

% Step response of T
figure;
step(T)
title("Question 2: Step Response of T - Benjamin Stutzke");

% Finding change in I
I = 1;
G = 1/((I*(s^2))*(s+1));
L_0 = minreal(G * H)
cross_freq = 0.43;
I = abs(evalfr(L_0, cross_freq*sqrt(-1)))
L = minreal(L_0/I)
figure;
bode(L)
title("Question 2: L with Minimum I - Benjamin Stutzke");

% Part E
I = 10;
L = minreal(L_0/I);
S = minreal(1/(1+L));

figure;
bode(S);
title("Question 2: Sensitivity Diagram - Benjamin Stutzke");
```

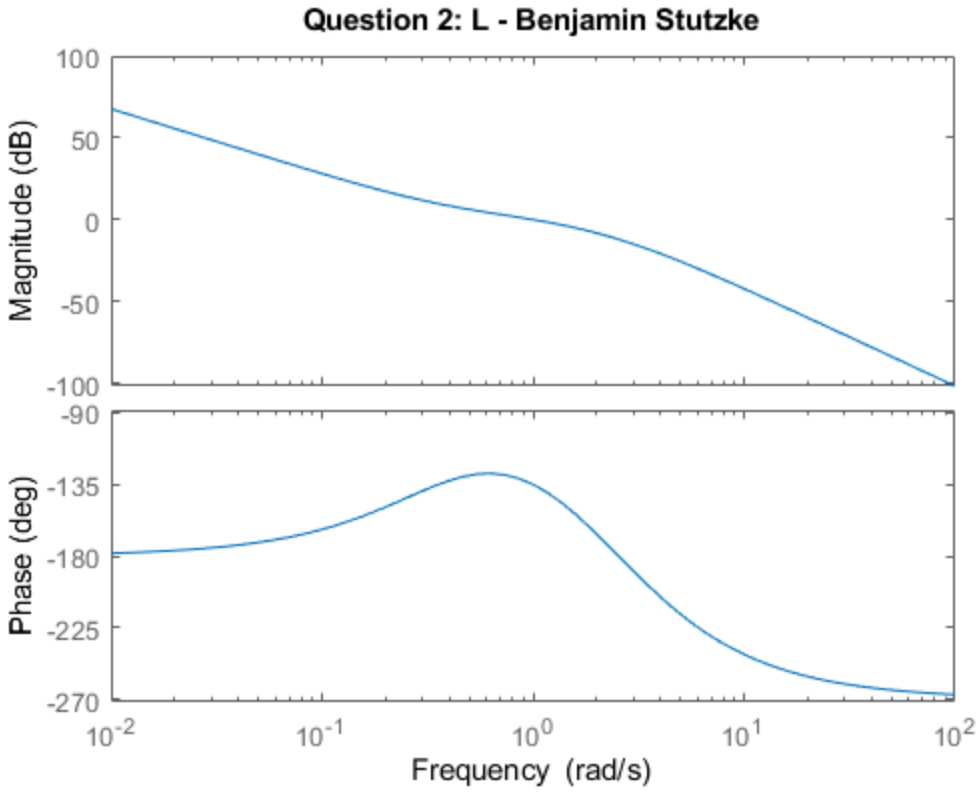
```
G =

         1
  ---------------
  10 s^3 + 10 s^2

Continuous-time transfer function.


angle_G =
```

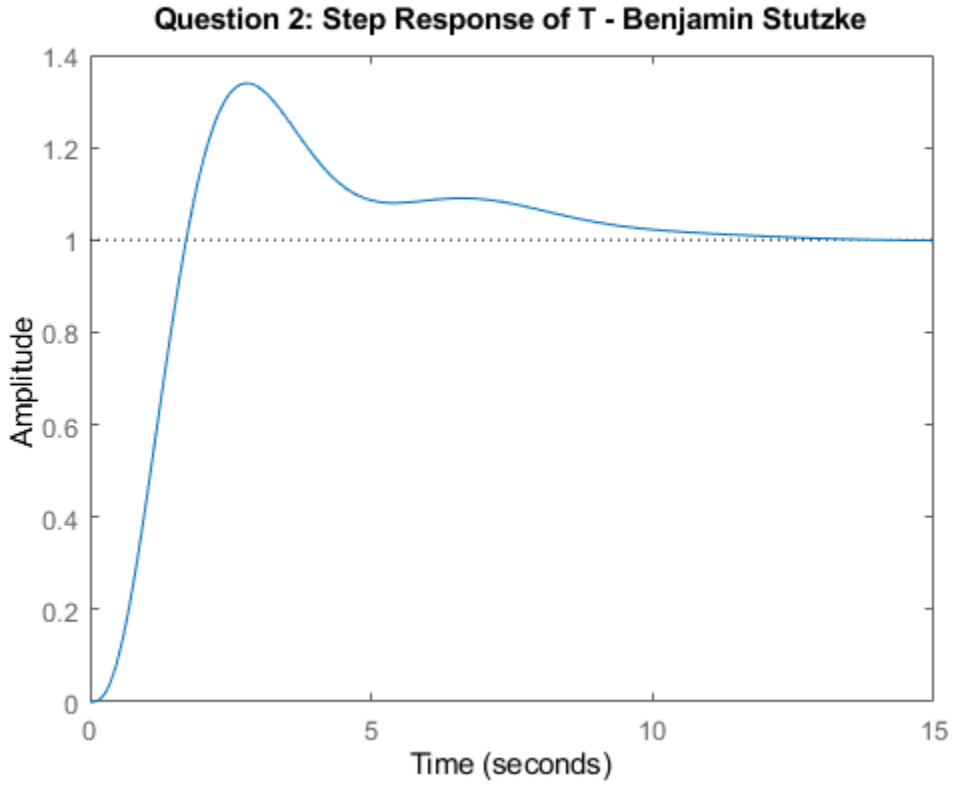
```
    2.3562

phi_req =

  -270

phi_req =

    90

phi_req =

    0.7854

b =

    5.8284

t =

    0.4142

H_10 =

  2.414 s + 1
  ------------
  0.4142 s + 1

Continuous-time transfer function.

H_0 =

  33.97 s^2 + 28.14 s + 5.828
  ---------------------------
     s^2 + 4.828 s + 5.828

Continuous-time transfer function.

L_0 =

       3.397 s^2 + 2.814 s + 0.5828
  -------------------------------------
  s^5 + 5.828 s^4 + 10.66 s^3 + 5.828 s^2

Continuous-time transfer function.
```

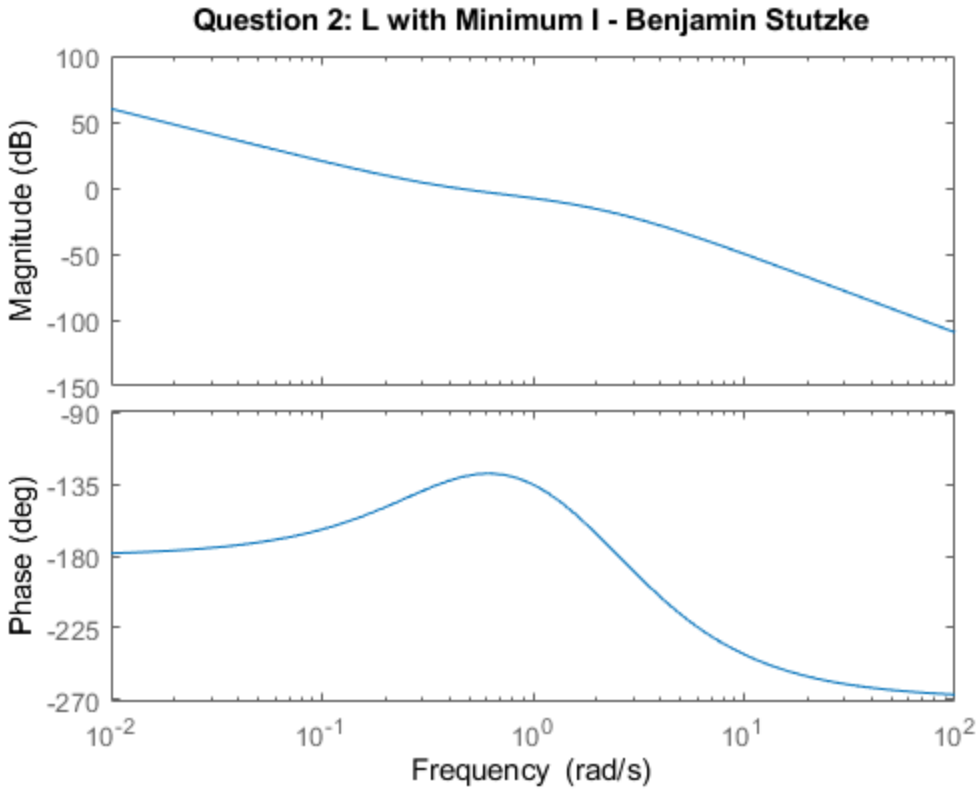
```
K =

    2.4264


ans =

   8.2426 (s+0.4142)^2
  ---------------------
  s^2 (s+2.414)^2 (s+1)

Continuous-time zero/pole/gain model.


ans =

                      8.2426 (s+0.4142)^2
  ------------------------------------------------------------
  (s+3.917) (s^2 + 0.6633s + 0.1658) (s^2 + 1.248s + 2.177)

Continuous-time zero/pole/gain model.


ans =

  -0.3316 + 0.2362i
  -0.3316 - 0.2362i


ans =

  -0.6240 + 1.3370i
  -0.6240 - 1.3370i


L_0 =

        82.43 s^2 + 68.28 s + 14.14
  ---------------------------------------
  s^5 + 5.828 s^4 + 10.66 s^3 + 5.828 s^2

Continuous-time transfer function.


I =

   24.2773


L =

       3.395 s^2 + 2.813 s + 0.5825
  ---------------------------------------
```

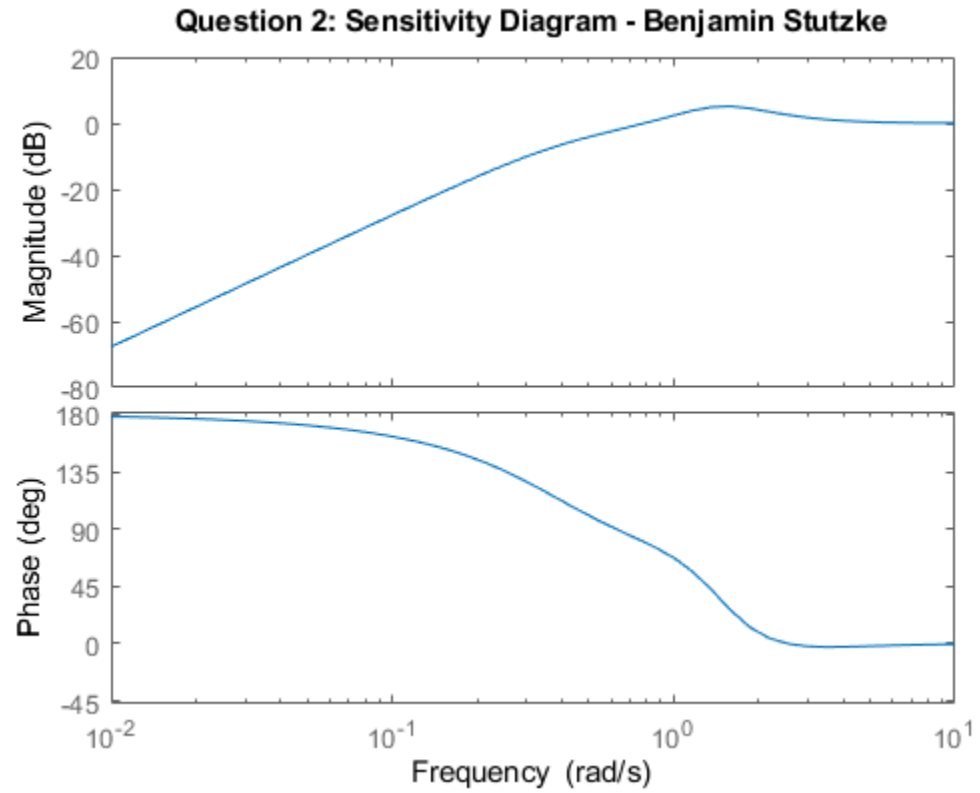
```
  s^5 + 5.828 s^4 + 10.66 s^3 + 5.828 s^2

Continuous-time transfer function.
```




Question 2: L - Benjamin Stutzke
Magnitude (dB)
100
50
0
-50
-100
Phase (deg)
-90
-135
-180
-225
-270
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
Frequency (rad/s)


Question 2: Step Response of T - Benjamin Stutzke
Amplitude
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
5
10
15
Time (seconds)


Question 2: L with Minimum I - Benjamin Stutzke
Magnitude (dB)
100
50
0
-50
-100
-150
Phase (deg)
-90
-135
-180
-225
-270
10^-2
10^-1
10^0
10^1
10^2
Frequency (rad/s)


Question 2: Sensitivity Diagram - Benjamin Stutzke
Magnitude (dB)
20
0
-20
-40
-60
-80
Phase (deg)
180
135
90
45
0
-45
10^-2
10^-1
10^0
10^1
Frequency (rad/s)

Question 3

```
s = tf('s');
I = 10;
b = 7.84;
t = 3.57;

% Part A
G = 1/((I*(s^2))*(s+1))
H_0 = (b*t*s + 1)/(t*s + 1)
L_0 = minreal(G * H_0)

% Finding L_0 at omega_des
z = 0.1i;
K = 1/abs(evalfr(L_0, z))

H = H_0 * K
L = minreal(G * H)

S = minreal(1/(1+L))
H = H/s
L = minreal(G * H)
```

```
G =

         1
  ---------------
  10 s^3 + 10 s^2

Continuous-time transfer function.


H_0 =

  27.99 s + 1
  -----------
  3.57 s + 1

Continuous-time transfer function.


L_0 =

       0.784 s + 0.02801
  ---------------------------
  s^4 + 1.28 s^3 + 0.2801 s^2

Continuous-time transfer function.


K =
```

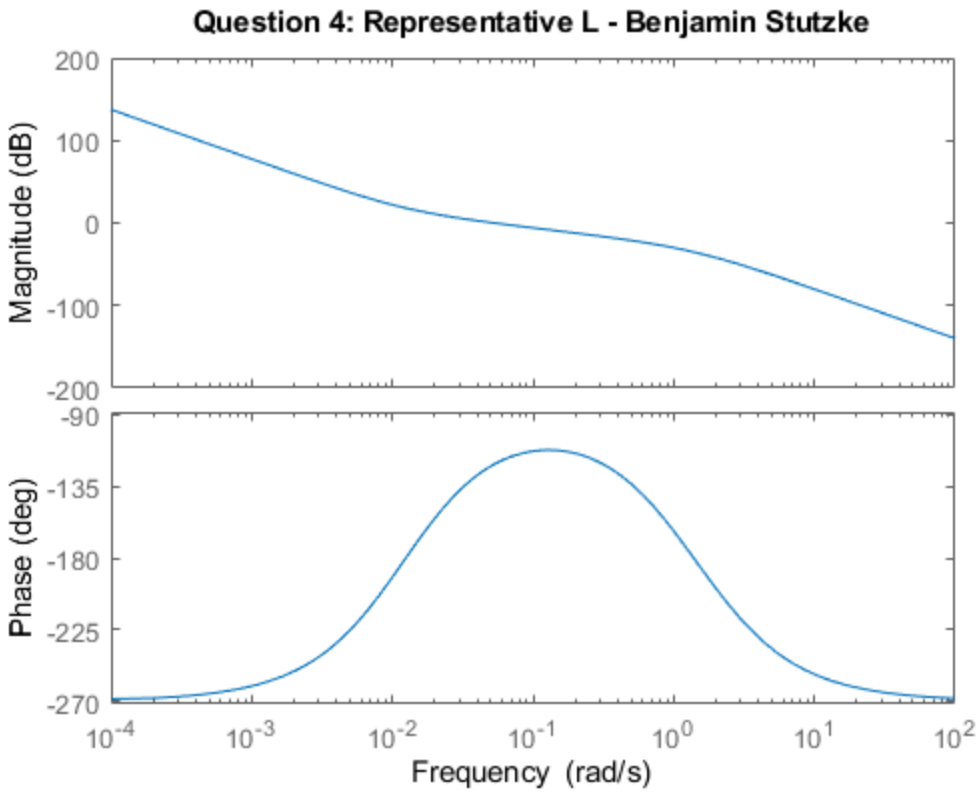
```
    0.0359


H =

  1.005 s + 0.0359
  ----------------
     3.57 s + 1

Continuous-time transfer function.


L =

     0.02815 s + 0.001006
  --------------------------
  s^4 + 1.28 s^3 + 0.2801 s^2

Continuous-time transfer function.


S =

             s^4 + 1.28 s^3 + 0.2801 s^2
  -------------------------------------------------
  s^4 + 1.28 s^3 + 0.2801 s^2 + 0.02815 s + 0.001006

Continuous-time transfer function.


H =

  1.005 s + 0.0359
  ----------------
    3.57 s^2 + s

Continuous-time transfer function.


L =

     0.02815 s + 0.001006
  --------------------------
  s^5 + 1.28 s^4 + 0.2801 s^3

Continuous-time transfer function.
```

Question 4

```
I = 10;
K = 1;
z1 = .01;
```

```
z2 = .015;
p1 = 2;

s = tf('s');
G = 1/((I*(s^2))*(s+1))
H = K*(s+z1)*(s+z2)/(s*(s+p1))

L = minreal(G*H)

figure;
bode(L)
title("Question 4: Representative L - Benjamin Stutzke");
```

```
G =

         1
  ---------------
  10 s^3 + 10 s^2

Continuous-time transfer function.


H =

  s^2 + 0.025 s + 0.00015
  -----------------------
         s^2 + 2 s

Continuous-time transfer function.


L =

  0.1 s^2 + 0.0025 s + 1.5e-05
  ----------------------------
      s^5 + 3 s^4 + 2 s^3

Continuous-time transfer function.
```



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