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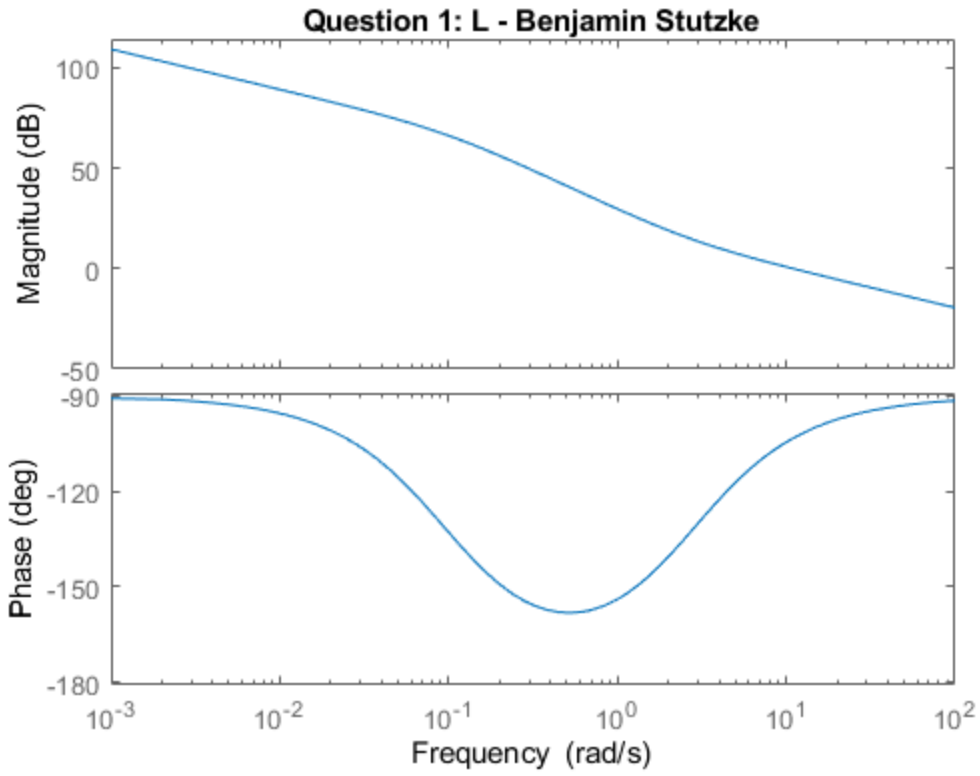
```
% Benjamin Stutzke
% ENAE432
% Problem Set 9
```

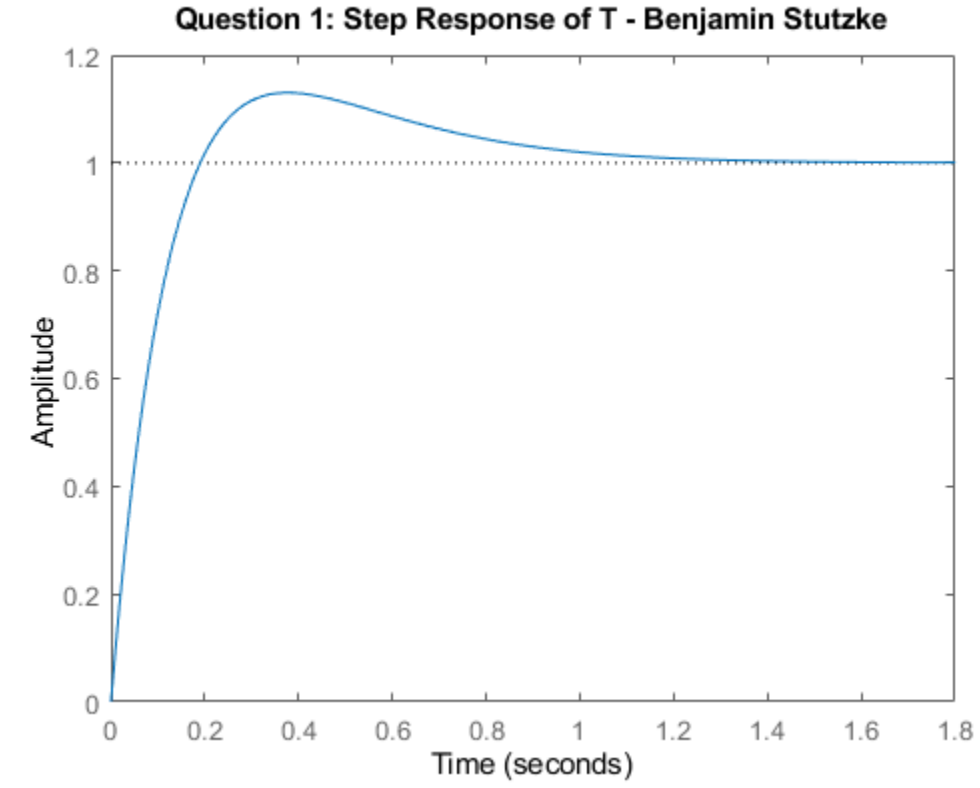
Question 1

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

Ki = 1;
Kp = 1;

% high end, somewhere around 100
Ki_range = 109:.01:120;

ki_diagnostic_array = zeros(1, length(Ki_range));
kp_diagnostic_array = zeros(1, length(Ki_range));
Ts_diagnostic_array = zeros(1, length(Ki_range));

for i=1:length(Ki_range)
    tempKi = Ki_range(i);
    tempKp = (sqrt(4*.26*tempKi) - .1)/.26;
    if(tempKp * 0.1 < tempKi)
        tempL = 0.26*tempKp*(s+(tempKi/tempKp))/(s*(s+0.1));
        tempT = minreal(tempL/(1+tempL));

        ts = stepinfo(tempT).SettlingTime;

        ki_diagnostic_array(i) = tempKi;
        kp_diagnostic_array(i) = tempKp;
        Ts_diagnostic_array(i) = ts;

        if(ts > 0.95 && ts < 1.001)
            Kp = tempKp;
            Ki = tempKi;
            break;
        end
    end
end

% Kp = 40.8203
% Ki = 110.36
```

```
L = 0.26*Kp*(s+(Ki/Kp))/(s*(s+0.1))
figure;
bode(L)
title("Question 1: L - Benjamin Stutzke");

T = minreal(L/(1+L))
figure;
step(T)
title("Question 1: Step Response of T - Benjamin Stutzke");

roots([1 (.26*Kp+0.1) (0.26*Ki)])
```

```
L =

  10.61 s + 28.69
  ---------------
    s^2 + 0.1 s

Continuous-time transfer function.


T =

     10.61 s + 28.69
  ----------------------
  s^2 + 10.71 s + 28.69

Continuous-time transfer function.


ans =

   -5.3566
   -5.3566
```


Question 1: L - Benjamin Stutzke
Magnitude (dB)
100
50
0
-50
Phase (deg)
-90
-120
-150
-180
10^-3
10^-2
10^-1
10^0
10^1
10^2
Frequency (rad/s)


Question 1: Step Response of T - Benjamin Stutzke
Amplitude
1.2
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
Time (seconds)

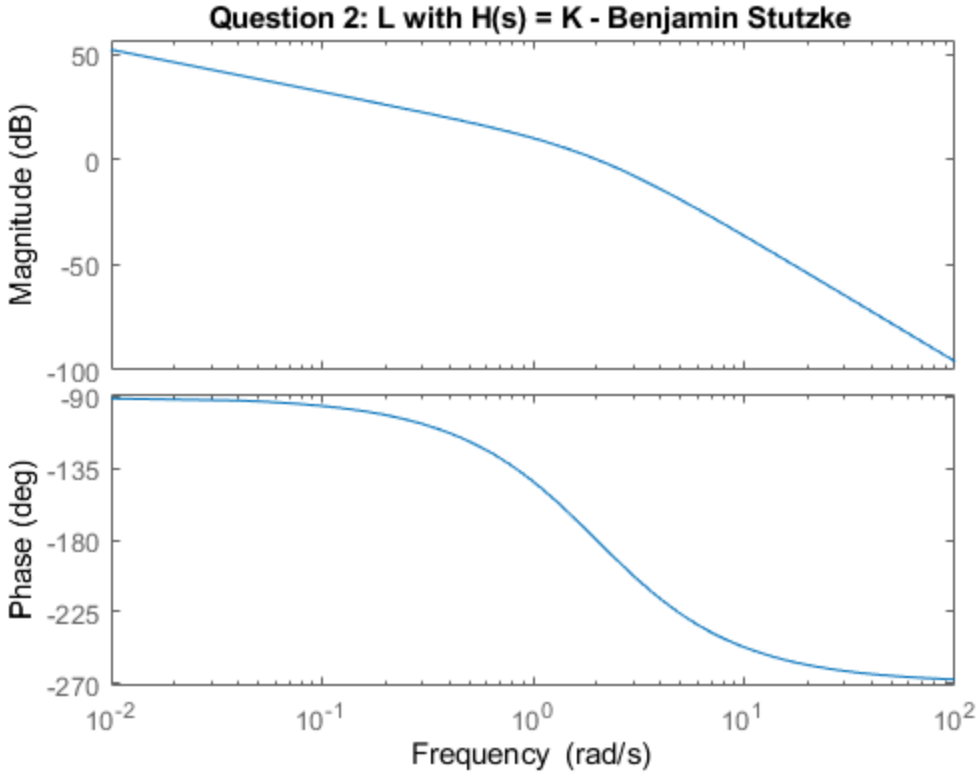
Question 2

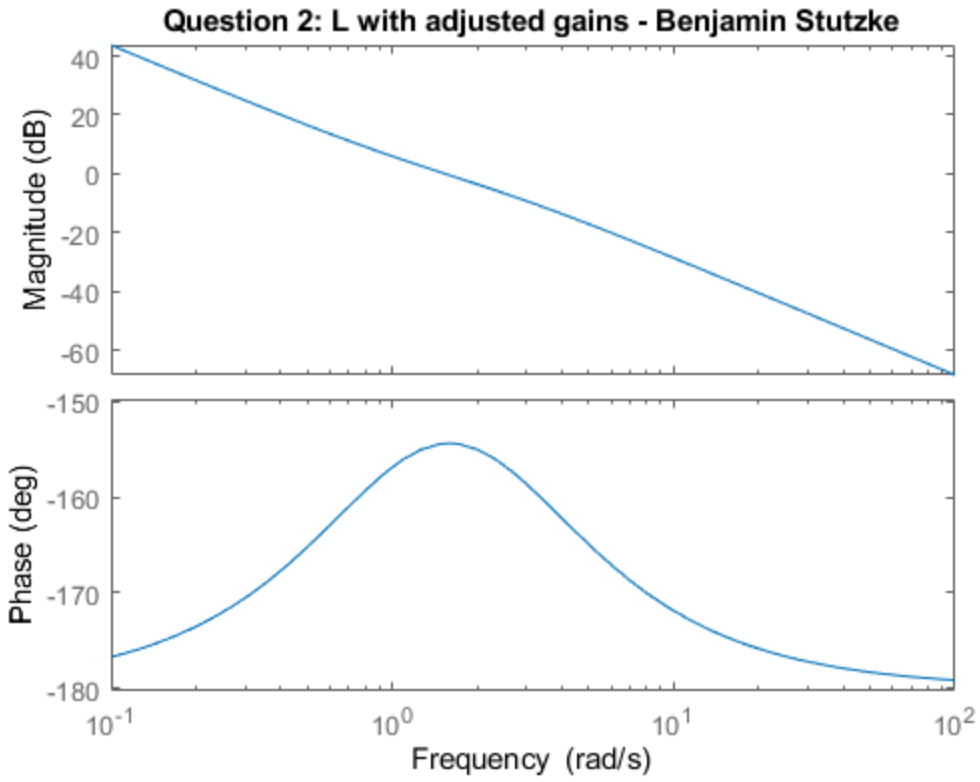
```
s = tf('s');
G = 4/(s*((s+2)^2))

K = 4;
H = K
L = minreal(G*H)

figure;
bode(L)
title("Question 2: L with H(s) = K - Benjamin Stutzke");

Ku = K;
Tu = pi;

Kp = (3/5)*Ku
Ki = 2*Kp/Tu
Kd = Kp*Tu/8

H = Kp + Kd*s + Ki/s

L = minreal(G*H)
1+L
figure;
bode(L)
title("Question 2: L with adjusted gains - Benjamin Stutzke");

roots([1 4 7.76 9.6 6.12])

T = minreal(L/(1+L))
figure;
step(T)
title("Question 2: Step Response of T - Benjamin Stutzke");
```

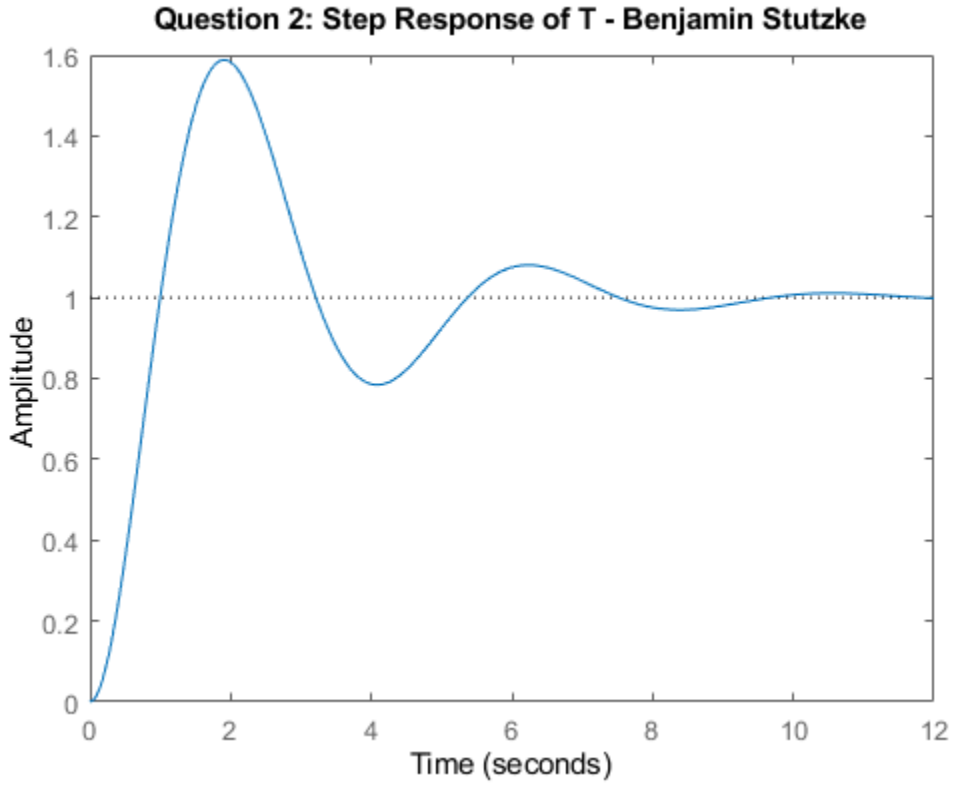
```
G =

          4
  -----------------
  s^3 + 4 s^2 + 4 s

Continuous-time transfer function.


H =

     4


L =

         16
```

```
  -----------------
  s^3 + 4 s^2 + 4 s

Continuous-time transfer function.


Kp =

    2.4000


Ki =

    1.5279


Kd =

    0.9425


H =

  0.9425 s^2 + 2.4 s + 1.528
  --------------------------
              s

Continuous-time transfer function.


L =

  3.77 s^2 + 9.6 s + 6.112
  ------------------------
    s^4 + 4 s^3 + 4 s^2

Continuous-time transfer function.


ans =

  s^4 + 4 s^3 + 7.77 s^2 + 9.6 s + 6.112
  --------------------------------------
           s^4 + 4 s^3 + 4 s^2

Continuous-time transfer function.


ans =

  -0.4532 + 1.4594i
  -0.4532 - 1.4594i
  -1.5468 + 0.4775i
  -1.5468 - 0.4775i
```

```
T =

          3.77 s^4 + 24.68 s^3 + 59.59 s^2 + 62.85 s + 24.45
  ------------------------------------------------------------------
  s^6 + 8 s^5 + 27.77 s^4 + 56.68 s^3 + 75.59 s^2 + 62.85 s + 24.45

Continuous-time transfer function.
```



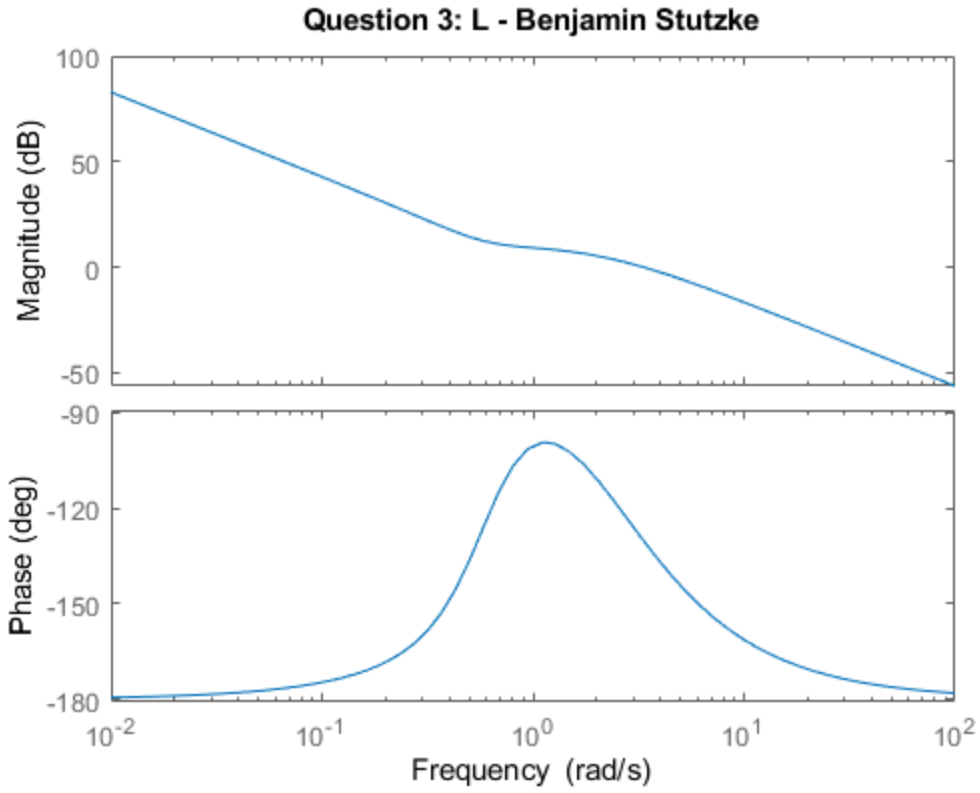

Question 2: L with adjusted gains - Benjamin Stutzke
Magnitude (dB)
40
20
0
-20
-40
-60
Phase (deg)
-150
-160
-170
-180
10^{-1}
10^{0}
10^{1}
10^{2}
Frequency (rad/s)

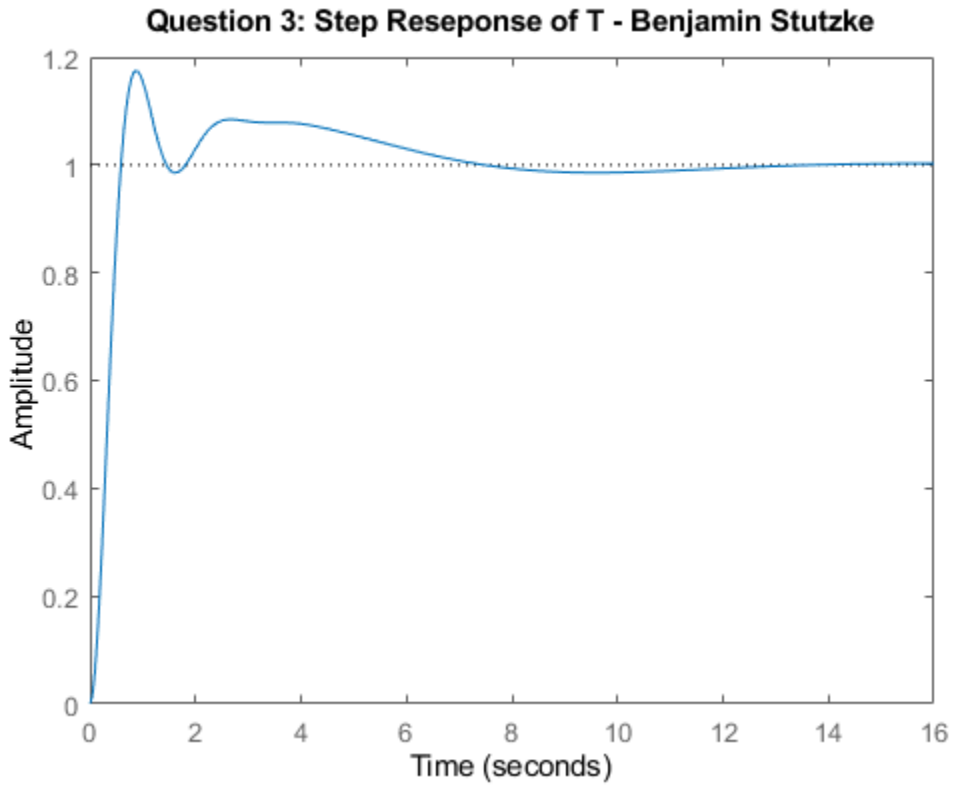

Question 2: Step Response of T - Benjamin Stutzke
Amplitude
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
Time (seconds)

Question 3

```
Ki = 1.385;
Kd = 2.75*Ki
Kp = .687*Kd

H = Kp + Kd*s + Ki/s
L = minreal(G*H)

figure;
bode(L)
title("Question 3: L - Benjamin Stutzke");

T = minreal(L/(1+L));
figure;
step(T)
title("Question 3: Step Reseponse of T - Benjamin Stutzke");
```

```
Kd =

    3.8087


Kp =

    2.6166


H =

  3.809 s^2 + 2.617 s + 1.385
  ---------------------------
               s

Continuous-time transfer function.


L =

  15.23 s^2 + 10.47 s + 5.54
  --------------------------
     s^4 + 4 s^3 + 4 s^2

Continuous-time transfer function.
```


Question 3: L - Benjamin Stutzke
Magnitude (dB)
100
50
0
-50
Phase (deg)
-90
-120
-150
-180
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
Frequency (rad/s)


Question 3: Step Reseponse of T - Benjamin Stutzke
Amplitude
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
16
Time (seconds)

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