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% Benjamin Stutzke  
% ENAE 432  
% Homework 10

## Question 1

```
zeta1 = 0.01;
zeta2 = 0.005;
omegal = 5;
omega2 = 20;
rho = 0.05;
I = 50;

s = tf('s');

n1 = (rho*s^2)*(s^2 + 2*zeta1*omegal*s + omega1^2)^(-1);
n2 = (rho*s^2)*(s^2 + 2*zeta2*omega2*s + omega2^2)^(-1);

G = 1/((I*s^2)*(1-(n1+n2)))
zpk(G)

figure(1);
bode(G);
title("Question 1: Bode Diagram of G - Benjamin Stutzke");

G0 = 1/(I*s^2)

figure(2);
bode(G0);
title("Question 1: Bode of G_0 - Benjamin Stutzke");

K = 1;
beta = 5.83;
tau = 0.828;

H0 = beta*tau*s+1 / (tau*s + 1);

K = 5.61;
H = H0 * K;

L0 = minreal(G0*H0);
L = minreal(G0 * H);
```

---

```
figure(3);
bode(L)
title("Question 1: Bode of L with simple model - Benjamin Stutzke");

T = minreal(L/(L+1));
figure(4);
step(T)
title("Question 1: Step of T with simple model - Benjamin Stutzke");
```

*G* =

$$\frac{s^4 + 0.3 s^3 + 425 s^2 + 45 s + 10000}{45 s^6 + 14.25 s^5 + 2.019e04 s^4 + 2250 s^3 + 500000 s^2}$$

*Continuous-time transfer function.*

*ans* =

$$\frac{0.022222 (s^2 + 0.1s + 25) (s^2 + 0.2s + 400)}{s^2 (s^2 + 0.1052s + 26.31) (s^2 + 0.2114s + 422.3)}$$

*Continuous-time zero/pole/gain model.*

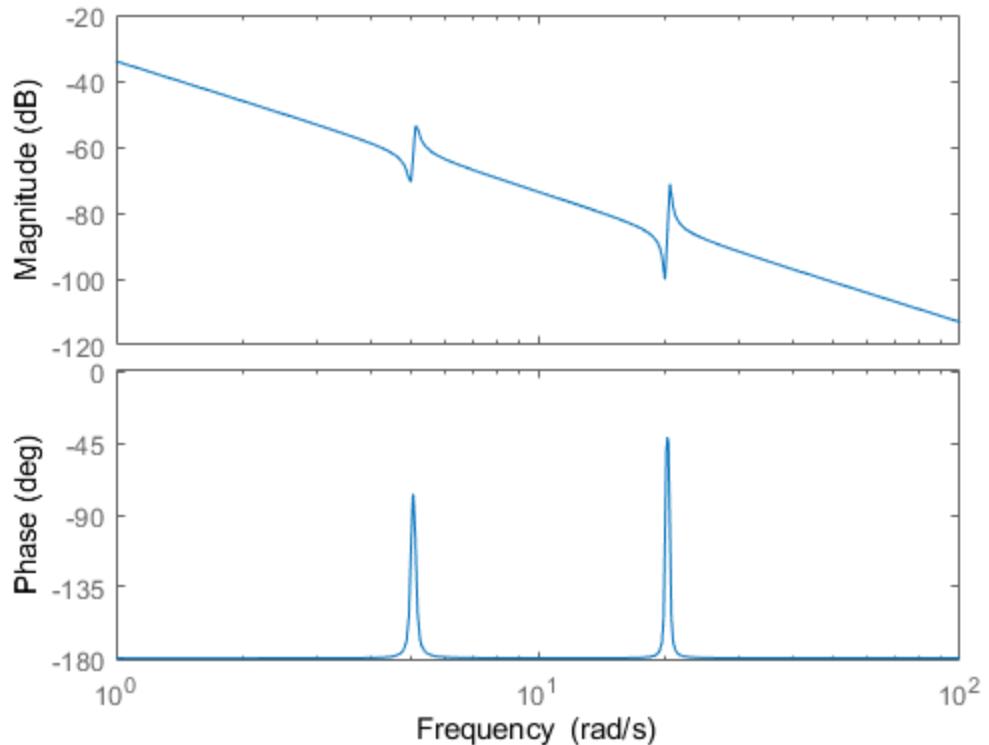
*G0* =

$$\frac{1}{50 s^2}$$

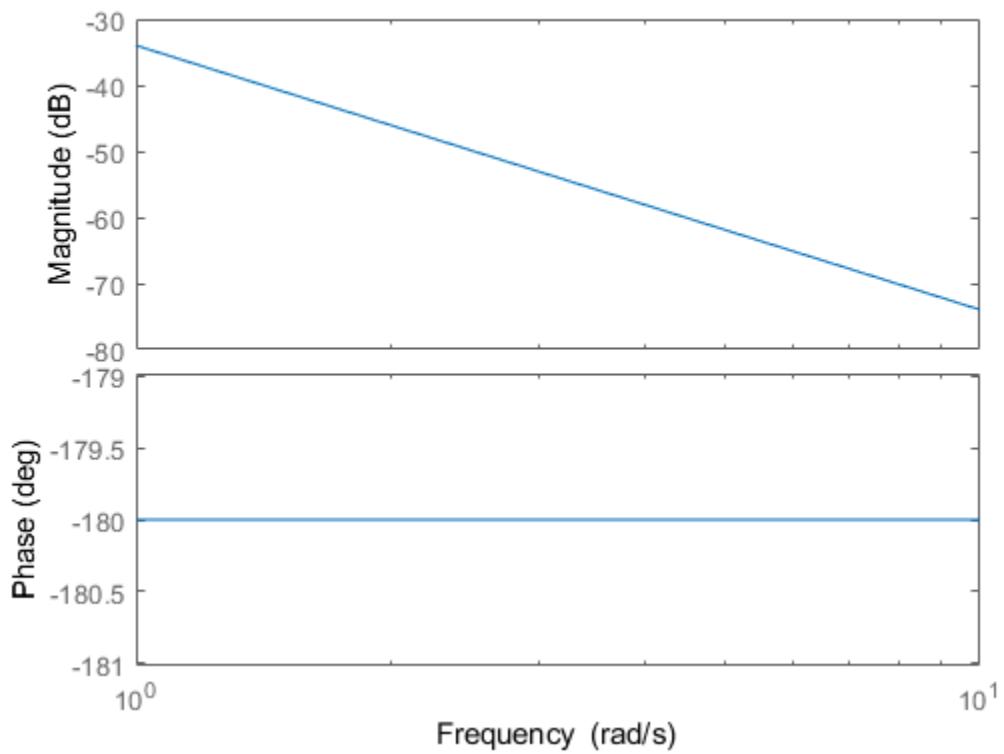
*Continuous-time transfer function.*

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**Question 1: Bode Diagram of G - Benjamin Stutzke**

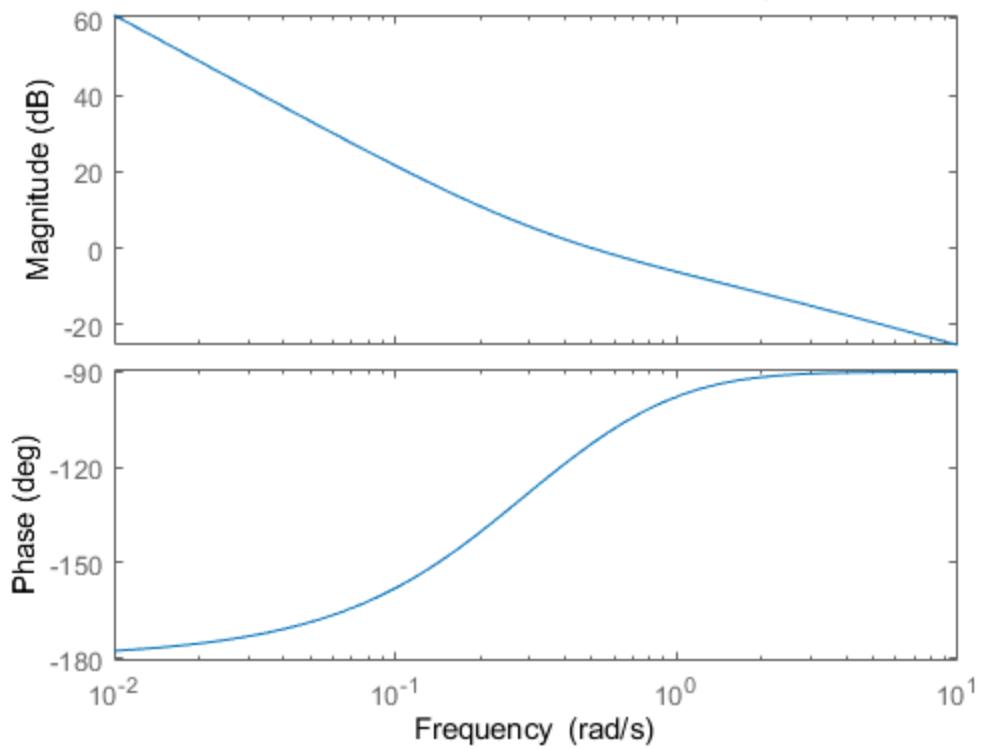


**Question 1: Bode of  $G_0$  - Benjamin Stutzke**

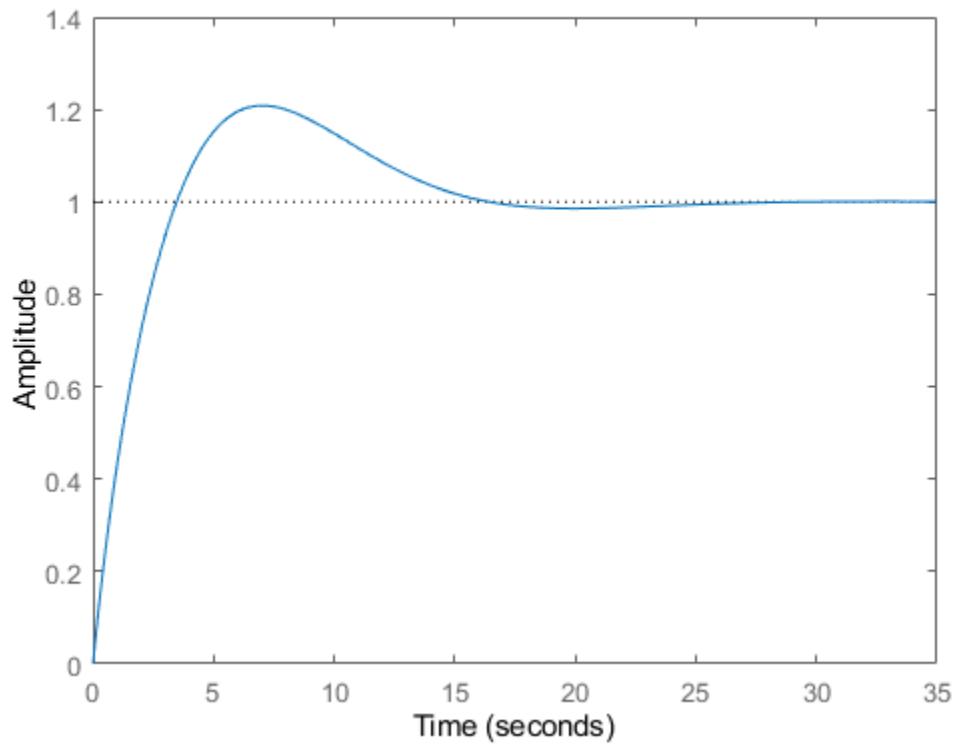


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**Question 1: Bode of L with simple model - Benjamin Stutzke**



**Question 1: Step of T with simple model - Benjamin Stutzke**



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## Question 2

```
L_actual = minreal(H*G);
figure(5);
bode(L)
title("Question 2: Bode of L with real model - Benjamin Stutzke");

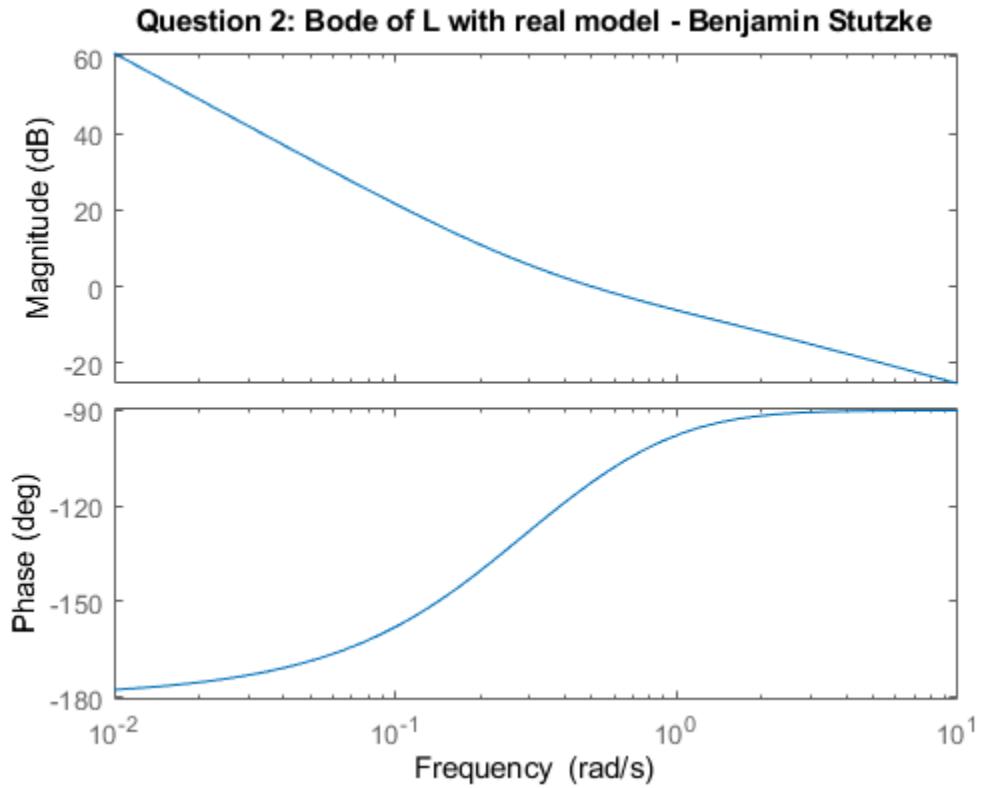
T_actual = minreal(L/(1+L));
figure(6);
step(T_actual, T);
legend("T", "T_0");
title("Question 2: Step comparison - Benjamin Stutzke");

delta = n1 + n2 / (1-n1-n2);

[Tmag, Tphase, Twout] = bode(T);

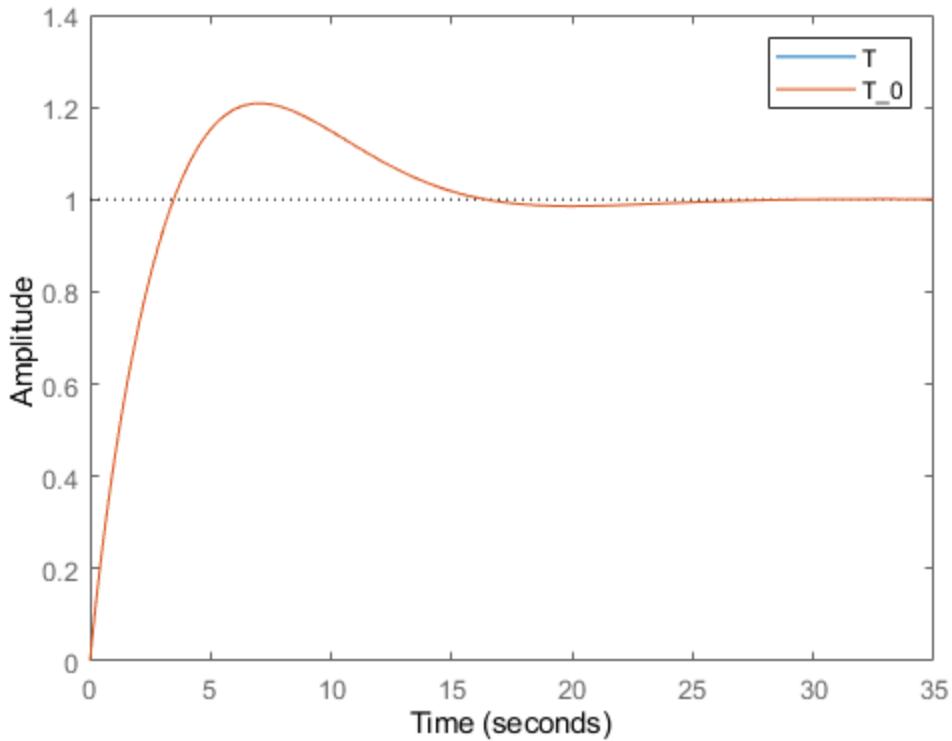
[invDmag, invDphase, invDwout] = bode(1/delta);

figure(7);
loglog(Twout, Tmag(:, :)')
hold on
loglog(invDwout, invDmag(:, :)')
title("Question 2: Comparing T0 to \Delta^{-1} - Benjamin Stutzke");
```

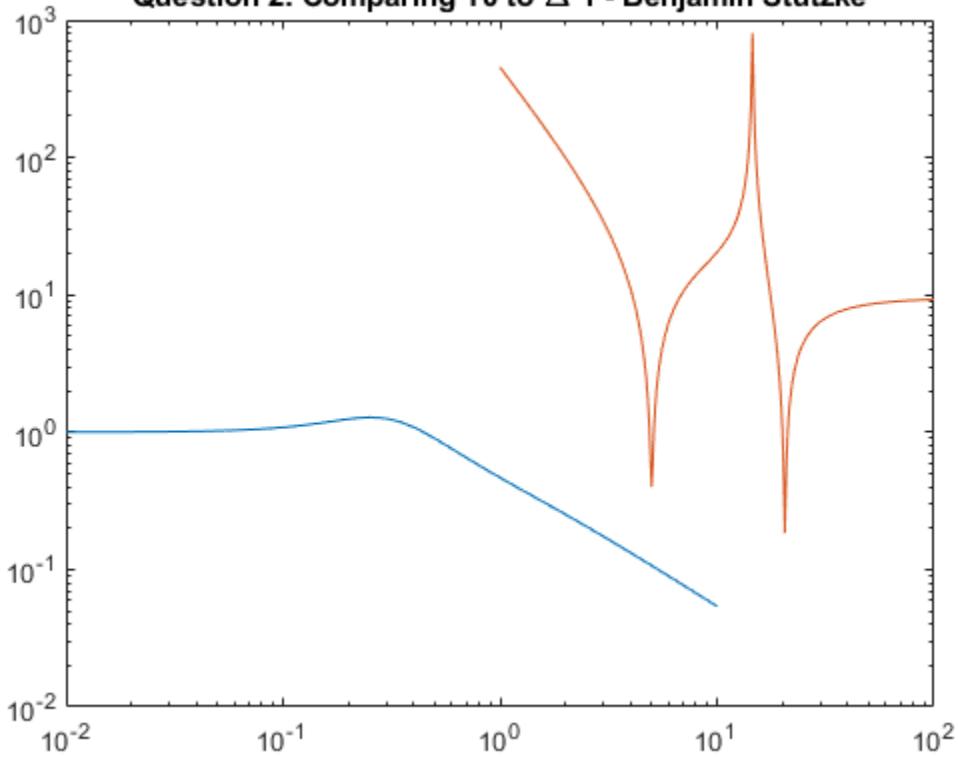


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### Question 2: Step comparison - Benjamin Stutzke



### Question 2: Comparing T0 to $\Delta^{-1}$ - Benjamin Stutzke



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## Question 3

```
s = tf('s');
K = 1;

L0 = 5/(s*(s+5)^3);

w = 0.1;
error = 0.0001;
step = 0.001;
breakpoint = 10000;

w_arr = zeros(1, breakpoint);
r_arr = zeros(1, breakpoint);

counter = 1;
while 1
    s = -1 + w*1i;
    ang = angle(evalfr(L0, s));

    r = rem(ang, pi);
    diff = abs(r) - pi;
    if diff < error && diff > -error
        break;
    end

    w_arr(counter) = w;
    r_arr(counter) = r;

    if counter == breakpoint
        break;
    end

    counter = counter + 1;
    w = w + step;
end
disp(w);
```

1.2060

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