Mikhail Grushko - BE110 - PSET 4

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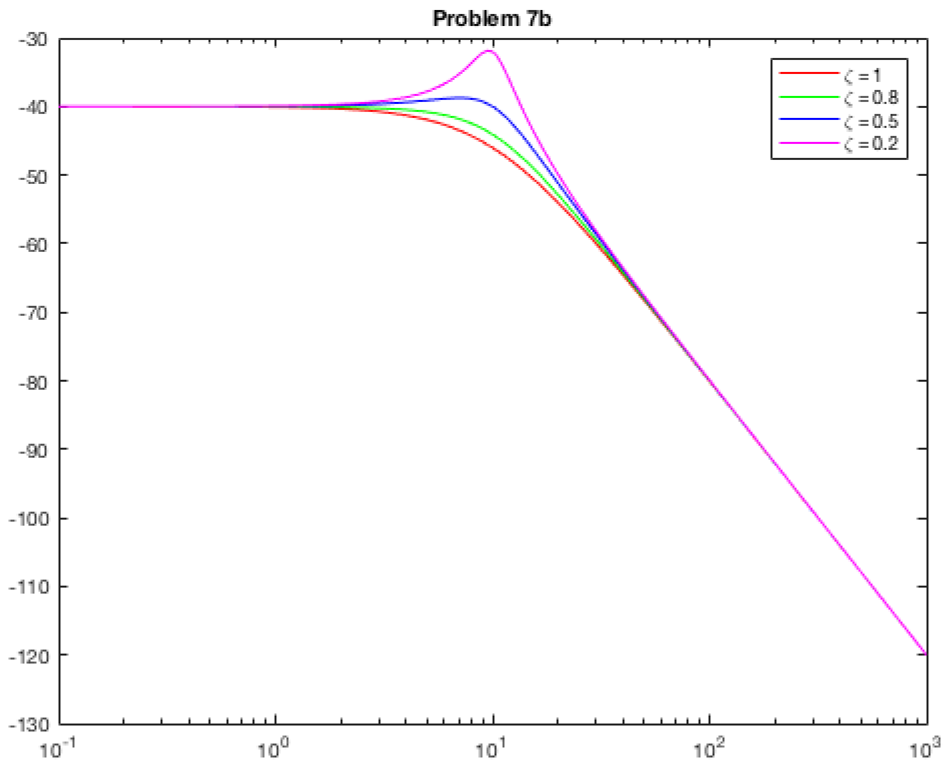
Cleanup

```
clearvars;
close all;
clc;
```

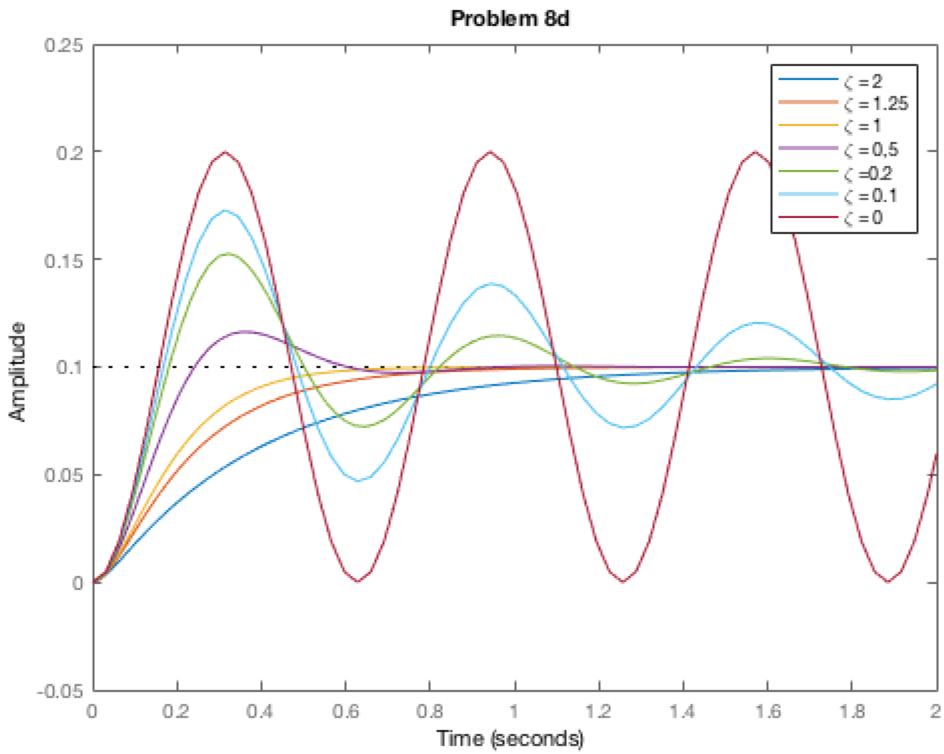
Problem 7b

```
j = sqrt(-1);
w = 10.^(-1 : 0.01 : 3);

w0 = 10;

zeta = [1, 0.8, 0.5, 0.2];

color = ['r', 'g', 'b', 'm'];

for i = 1 : 4
    H = 1./((j*w).^2+2*zeta(i)*w0*(j*w)+w0^2);
    Hdb=20*log10(abs(H));
    plot(w,Hdb,color(i));
    set(gca,'xscale','log')
    hold on;
end
title('Problem 7b');
legend('\zeta = 1', '\zeta = 0.8', '\zeta = 0.5', '\zeta = 0.2');
```



Problem 8d

```
zeta = [2, 1.25, 1, 0.5, 0.2, 0.1, 0];
b = zeta*2*0.1*10;
j = sqrt(-1);
w = ifft(10.^(-1 : 0.01 : 3));
color = ['r', 'g', 'b', 'm', 'k', 'c', 'k'];

figure;
for i = 1 : 7
    H = tf(10, [1, 2*zeta(i)*w0, w0^2]);
    step(H);
    xlim([0 2])
    hold on;
end
title('Problem 8d');
legend('\zeta = 2', '\zeta = 1.25', '\zeta = 1', '\zeta = 0,5', '\zeta
 =0.2', '\zeta = 0.1' , '\zeta = 0');
```



What is going here is that as we decrease \zeta from 2 to 0, we get a higher and higher peak values, until eventually @ $\zeta = 0$, we get an infinitely large peak. This is due to the fact that the system's denominator $- > 0$ as $\zeta - > 0$

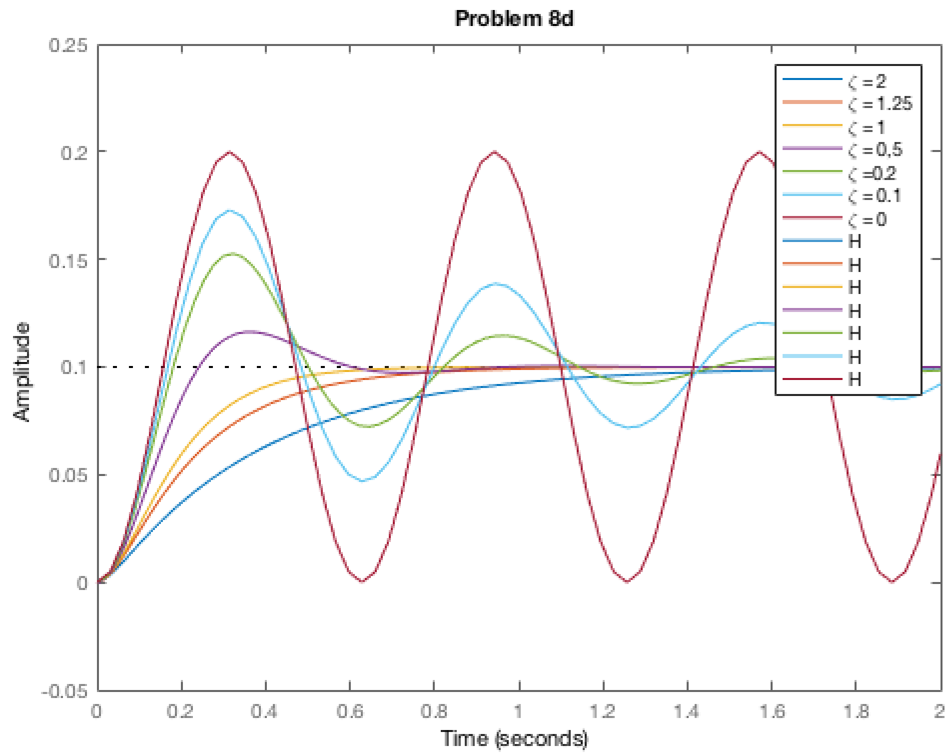
Problem 8e

```
j = sqrt(-1);
w = 10.^(-1 : 0.01 : 3);
zeta = [2, 1.25, 1, 0.5, 0.2, 0.1, 0];
K = 10;
w0 = 10;
color = ['r', 'g', 'b', 'm', 'k', 'c', 'k'];

for i = 1 : 7
    H = tf(10, [1, 2*zeta(i)*w0, w0^2]);
    step(H);
    xlim([0 2])
    hold on;
    sys=tf(K, [1, 2*zeta(i)*w0, w0^2]);
    Y = stepinfo(sys)
end
```

```
Y =

  struct with fields:
```

```
        RiseTime: 0.8231
    SettlingTime: 1.4879
     SettlingMin: 0.0902
     SettlingMax: 0.0999
       Overshoot: 0
      Undershoot: 0
            Peak: 0.0999
        PeakTime: 2.7327


Y =

  struct with fields:

        RiseTime: 0.4624
    SettlingTime: 0.8400
     SettlingMin: 0.0901
     SettlingMax: 0.0999
       Overshoot: 0
      Undershoot: 0
            Peak: 0.0999
        PeakTime: 1.4230


Y =

  struct with fields:

        RiseTime: 0.3359
    SettlingTime: 0.5835
     SettlingMin: 0.0901
     SettlingMax: 0.1000
       Overshoot: 0
      Undershoot: 0
            Peak: 0.1000
        PeakTime: 1.1900


Y =

  struct with fields:

        RiseTime: 0.1639
    SettlingTime: 0.8076
     SettlingMin: 0.0932
     SettlingMax: 0.1163
       Overshoot: 16.2929
      Undershoot: 0
            Peak: 0.1163
        PeakTime: 0.3592


Y =
```

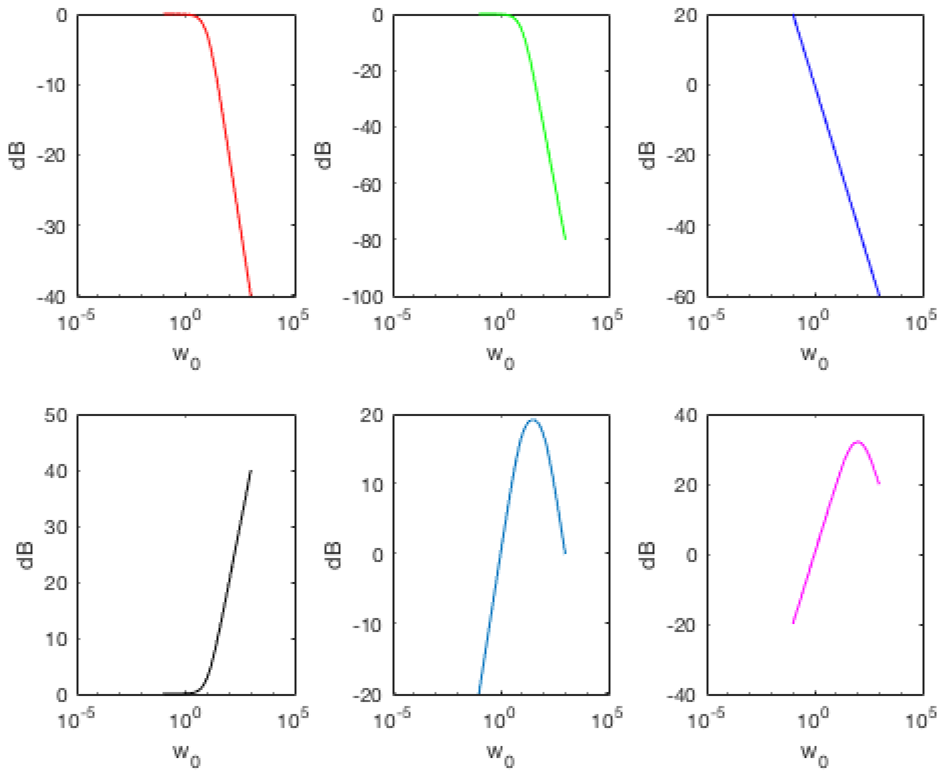
```
  struct with fields:

        RiseTime: 0.1206
    SettlingTime: 1.9596
     SettlingMin: 0.0723
     SettlingMax: 0.1527
       Overshoot: 52.6542
      Undershoot: 0
            Peak: 0.1527
        PeakTime: 0.3224


Y =

  struct with fields:

        RiseTime: 0.1127
    SettlingTime: 3.8373
     SettlingMin: 0.0468
     SettlingMax: 0.1729
       Overshoot: 72.9156
      Undershoot: 0
            Peak: 0.1729
        PeakTime: 0.3142


Y =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf
```



Problem 9

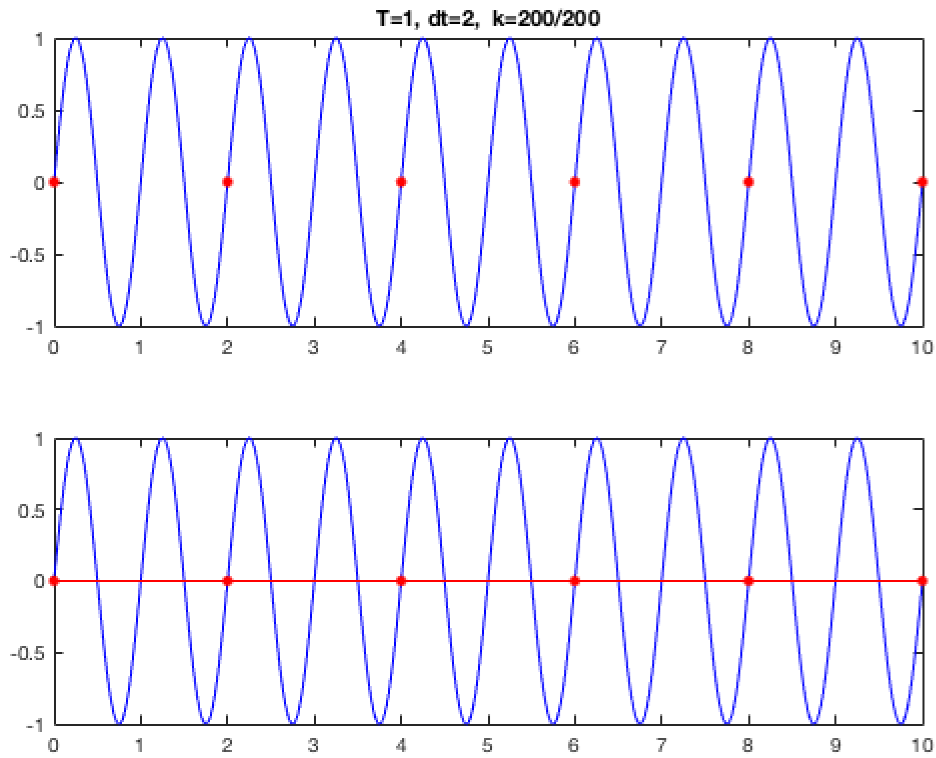
```
w = 10.^(-1 : 0.01 : 3);

figure;
subplot(2,3,1);
H=1./(j*w/10+1);
Hdb=20*log10(abs(H));
plot(w,Hdb,'r');
set(gca,'xscale','log')% define H & make the plot
xlabel('w_0')
ylabel('dB')

subplot(2,3,2);
H=1./(j*w/10+1).^2;
Hdb=20*log10(abs(H));
plot(w,Hdb,'g');
set(gca,'xscale','log')% define H & make the plot
xlabel('w_0')
ylabel('dB')

subplot(2,3,3);
H=1./(j*w);
Hdb=20*log10(abs(H));
plot(w,Hdb,'b');
```

```
set(gca,'xscale','log')% define H & make the plot
xlabel('w_0')
ylabel('dB')

subplot(2,3,4);
H=((j*w)./10)+1;
Hdb=20*log10(abs(H));
plot(w,Hdb,'k');
set(gca,'xscale','log')% define H & make the plot
xlabel('w_0')
ylabel('dB')

subplot(2,3,5);
H=(j*w)./(((j*w./10) + 1).*((j*w./100) + 1));
Hdb=20*log10(abs(H));
plot(w,Hdb);
set(gca,'xscale','log')% define H & make the plot
xlabel('w_0')
ylabel('dB')

subplot(2,3,6);
H=(j*w)./(((j*w./50) + 1).*((j*w./200) + 1));
Hdb=20*log10(abs(H));
plot(w,Hdb,'m');
set(gca,'xscale','log')% define H & make the plot
xlabel('w_0')
ylabel('dB')
```



Problem 10a

```
figure;
t=0:.01:10;
x=sin(2*pi*t);
% define t with an initial sampling interval dt=0.01 and define x(t)to
 have
% period=1
for k=1:200
% for loop that incrementally changes the sampling interval
    is=1:k:length(t);
    ts=t(is);
    xs=x(is);
    %set the new dt tok*dt&then plot the original x (blue) and the
 sampled x(red)
    subplot(211);
    plot(t,x,'-b',ts, xs,'.r','markersize',16);
    title(['T=1, dt=',num2str(k*0.01), ',  k=',num2str(k),'/200']);
    subplot(212); plot(t,x,'-b',ts, xs,'.-r','markersize',16); pause
    % hit the SPACEBAR to advance to next plot
end
% this code flips thorough sampling rates.  The lower plots is the
 same as
% the upperbut with the reddots connected
```

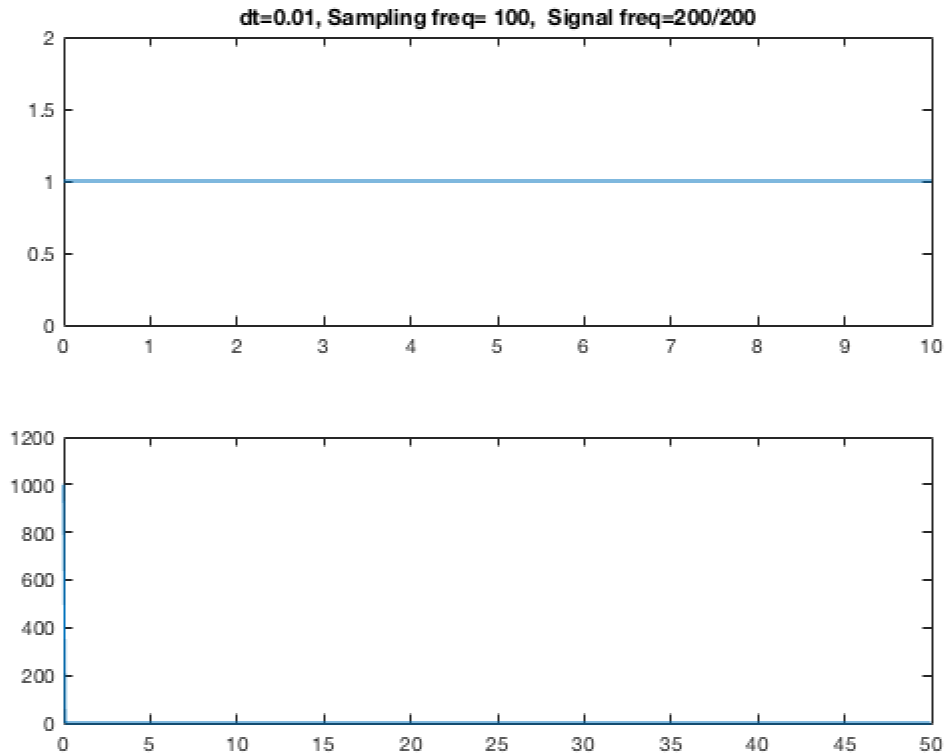


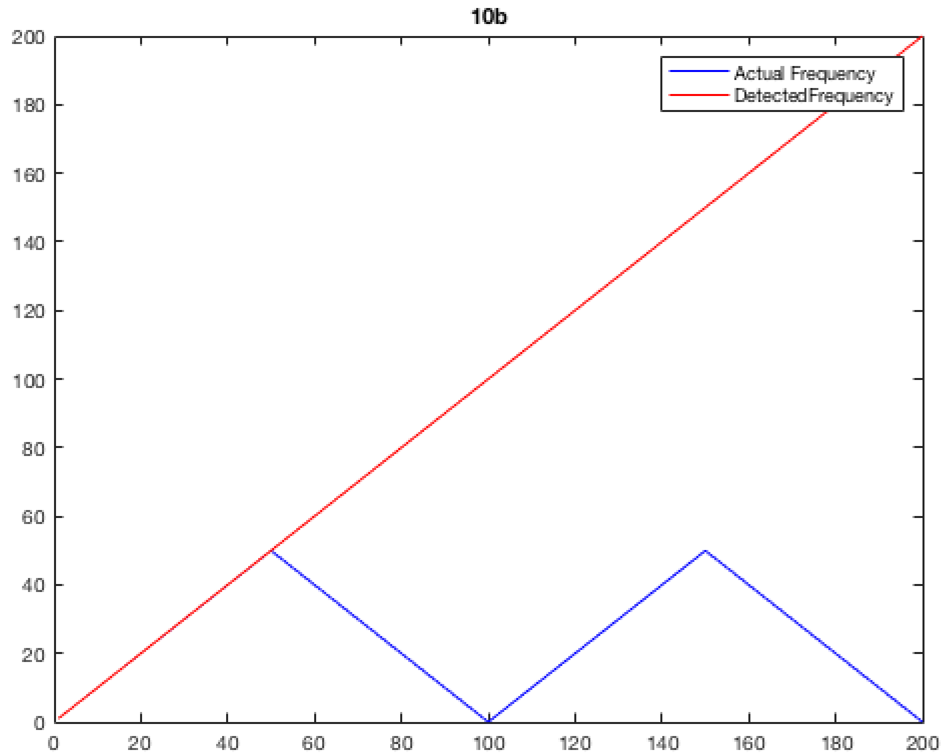
10a: As I am flipping through the sampling frequencies, I observe the effect known as aliasing. Aliasing is generally observed in the Discrete-Time Fourier Transform, where only a single fundamental sampling frequency ω_o. At higher ω_o (significantly higher than period T), the DTFT does an accurate job of representing the original wave. However, at $\omega_o = 0.5T$, aliasing effect begins to occur, due to the fact that one cannot unambiguously interpret the samples, creating multiple signals that are aliases of each other (i.e. all of the aliases can produce the sampling obtained).

Problem 10b

```
figure;
dt=0.01;
t=0:dt:10;
N=length(t);
% define t with a sampling interval dt=0.001
for k=1:200
% for loop that incrementally changes the frequency
    x=cos(2*pi*k*t);
 %set the new frequencytok
 subplot(211);
 plot(t,x);
 title(['dt=0.01, Sampling freq= 100,  Signal
 freq=',num2str(k),'/200']);
 % plot x(t)
 X=fft(x);
 X=X(1:round(N/2)); f=(0:round(N/2)-1)/(N*dt);
```

```
 % findthe DFT of x(t) thenremove the redundant freqs
 subplot(212);
 plot(f,abs(X));% plot X(f)in the lowerplot
    [a, b] = max(X);
 f_actual(k)= k;
 f_detected(k)= f(b); %MODIFY THIS LINE
    pause;
 % pressthe SPACEBAR to advance to next frame(or hold it downto
 advance rapidlly)\
end

figure;
plot(f_actual, f_detected, '-b',f_actual, f_actual, '-r');
legend({'Actual Frequency','DetectedFrequency'})
title('10b')
```





This is another way of demonstrating the aliasing problem when doing the Discrete-Time Fourier Transform. However, this time we're exploring DTFTs at different signal ω_o, but the same sampling frequency. What happens as we move towards higher signal frequencies, we see repeating frequencies, which is a sign of aliasing. The pattern also follows the Nyquist law, which states that a signal must be sampled at a rate greater twice as ω_o.

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