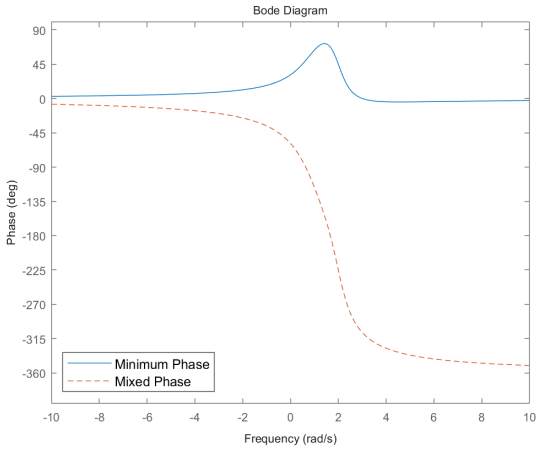
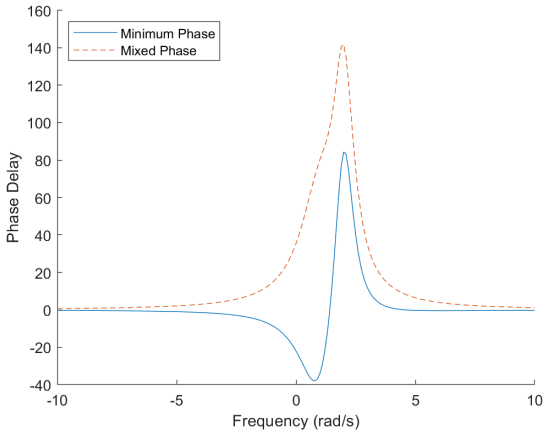
Problem 1

```
clearvars; clc;
opts = bodeoptions;
opts.FreqScale = 'linear';
opts.MagVisible = 'off';
opts.PhaseMatching = 'on';
opts.PhaseMatchingFreq = 1;
opts.PhaseMatchingValue = 0;
z_0 = -1 + 1i;
p_0 = -0.5 + 2i;
k_0 = 1.0;
z_1 = 1 + 1i;
p_1 = -0.5 + 2i;
k_1 = 1.0;
sys_0 =  zpk(z_0, p_0, k_0);
sys_1 =  zpk(z_1, p_1, k_1);
[num0,den0] = zp2tf(z_0, p_0,
k_0);
[num1,den1] = zp2tf(z_1, p_1,
k_1);
w = -10:0.1:10;
```

```
figure()
bp0 = bodeplot(sys_0,sys_1, '--',w, opts);
legend("Minimum Phase", "Mixed Phase",
Location='Southwest')
[mag0,phase0,wout0] = bode(sys_0,w);
[mag1,phase1,wout1] = bode(sys_1,w);
phase0 = reshape(phase0,[],1);
phase1 = reshape(phase1,[],1);
figure()
hold on
phase_delay0 = -gradient(phase0, wout0);
plot(wout0, phase_delay0)
phase_delay1 = -gradient(phase1, wout1);
plot(wout1, phase_delay1,'--')
xlabel('Frequency (rad/s)')
ylabel('Phase Delay')
legend('Minimum Phase', 'Mixed Phase',
Location='Northwest')
hold off
```

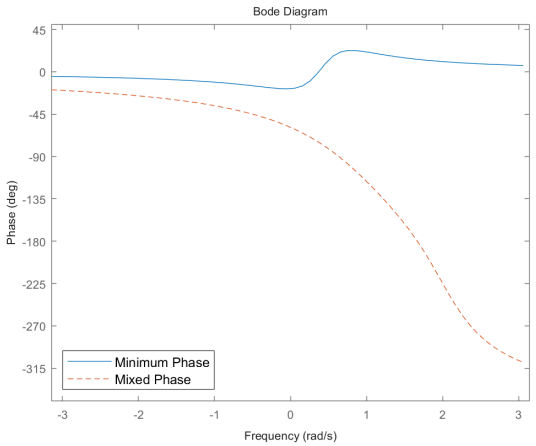


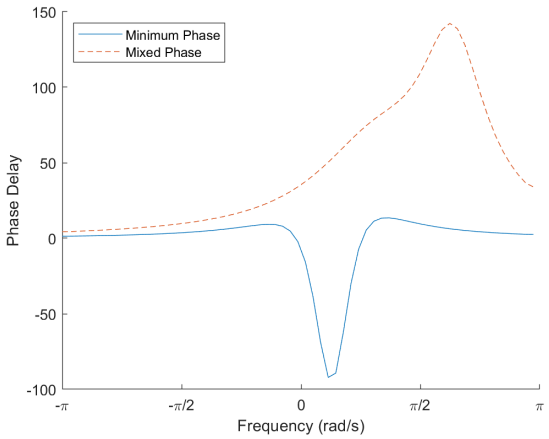


Problem 2

```
clearvars; clc;
xlims = [-pi pi];
opts = bodeoptions;
opts.FreqScale = 'linear';
opts.MagVisible = 'off';
opts.PhaseMatching = 'on';
opts.PhaseMatchingFreq = 1;
opts.PhaseMatchingValue = 0;
opts.XLim = xlims;
z_0 = 0.75*exp(0.2i*pi);
p_0 = 0.5*exp(0.3i*pi);
k_0 = 1.0;
z_1 = 1 + 1i;
p_1 = -0.5 + 2i;
k_1 = 1.0;
ts = 0.1;
sys_0 =  zpk(z_0, p_0, k_0);
sys_1 =  zpk(z_1, p_1, k_1);
[num0,den0] = zp2tf(z_0, p_0, k_0);
[num1,den1] = zp2tf(z_1, p_1, k_1);
w = -pi:0.1:pi;
```

```
figure()
bp0 = bodeplot(sys_0,sys_1, '--',w, opts);
legend("Minimum Phase", "Mixed Phase",
Location='Southwest')
[mag0,phase0,wout0] = bode(sys_0,w);
[mag1,phase1,wout1] = bode(sys_1,w);
phase0 = reshape(phase0,[],1);
phase1 = reshape(phase1,[],1);
figure()
hold on
phase_delay0 = -gradient(phase0, wout0);
plot(wout0, phase_delay0)
phase_delay1 = -gradient(phase1, wout1);
plot(wout1, phase_delay1,'--')
xlabel('Frequency (rad/s)')
ylabel('Phase Delay')
XTickLabel = {'-\pi','-\pi/2','0','\pi/2','\pi'};
legend('Minimum Phase', 'Mixed Phase',
Location='Northwest')
set(gca,'XTick',-pi:pi/2:pi)
set(gca,'XTickLabel',XTickLabel)
set(gca,'xlim',[-pi, pi])
hold off
```



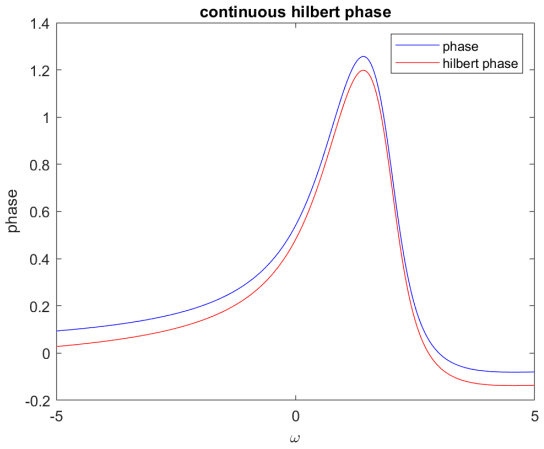


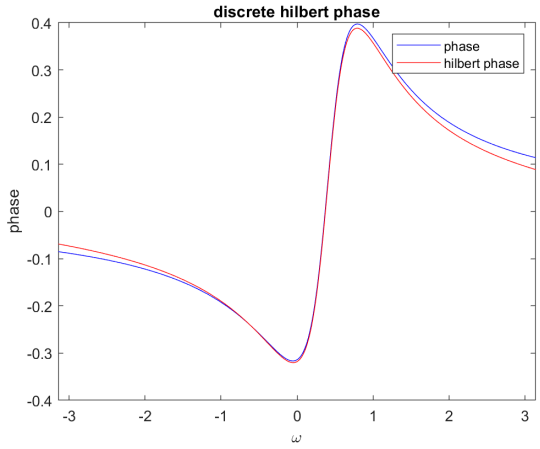
Problem 3

```
clc;clearvars;
z_0 = -1 + 1i;
p_0 = -0.5 + 2i;
k_0 = 1.0;
z_1 = 0.75*exp(0.2i*pi);
p_1 = 0.5*exp(0.3i*pi);
k_1 = 1.0;
sys_0 = zpk(z_0, p_0, k_0);
sys_1 = zpk(z_1, p_1, k_1);

w0 = -20:0.001:20;
[mag0, phase0, wout] = bode(sys_0,w0);
phase0 = deg2rad(reshape(phase0,[],1));
mag0 = reshape(mag0,[],1);
hr_0 = -imag(hilbert(log(mag0)));
f
```

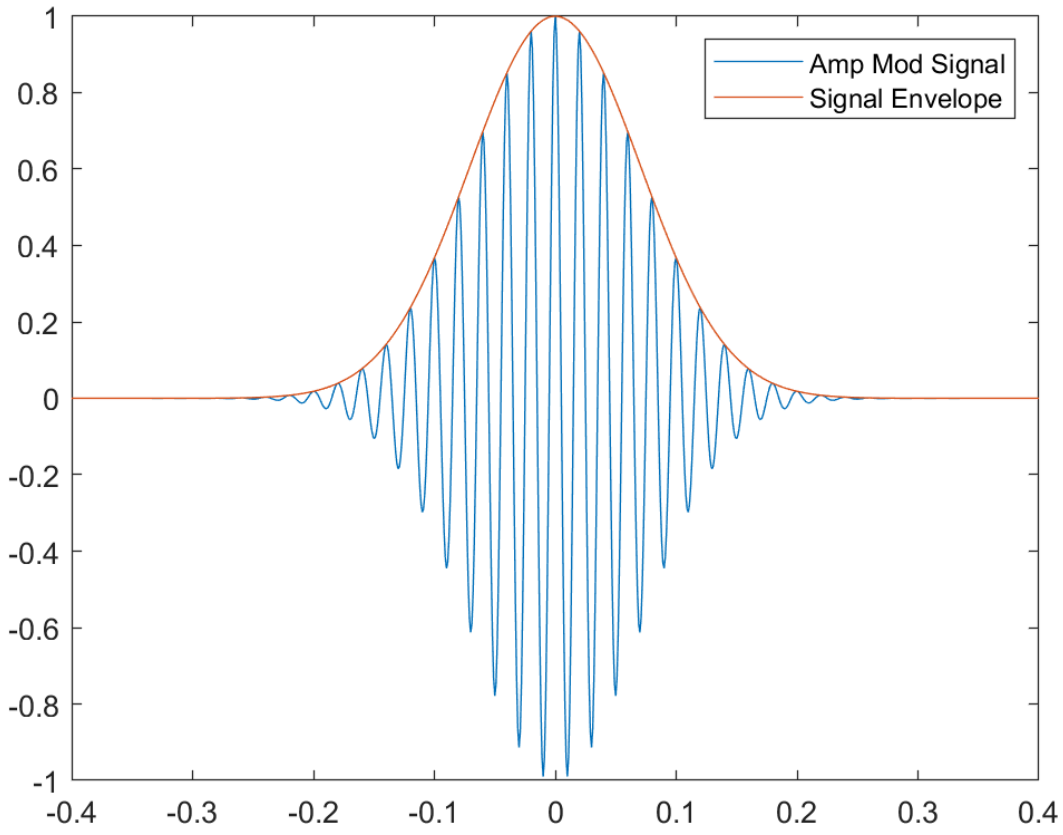
```
figure;
plot(wout, phase0, 'b', wout, hr_0, 'r');
xlim([-5, 5]);
legend('phase', 'hilbert phase')
ylabel('phase')
xlabel('\omega')
xtitle('continuous hilbert phase')
w1 = -2*pi:0.001:2*pi;
[mag1, phase1, wout] = bode(sys_1,w1);
phase1 = deg2rad(reshape(phase1,[],1));
mag1 = reshape(mag1,[],1);
hr_1 = imag(hilbert(log(mag1)));
figure;
plot(wout, phase1, 'b', wout, hr_1, 'r');
xlim([-pi, pi]);
legend('phase', 'hilbert phase')
ylabel('phase')
xlabel('\omega')
xtitle('discrete hilbert phase')
```





Problem 4

```
fs = 1000;
t = -4:1/fs:4;
size(t)
f0 = 50;
n = 1:8001;
hn = (2./(pi*n)) .* (sin(pi*n/2)).^2;
xt = cos(2*pi*f0*t).*exp(-100*t.^2);
ana_xt = hilbert(xt);
envelope = abs(ana_xt);
plot(t, xt, t, envelope);
xlim([-0.4 0.4])
legend('Amp Mod Signal', 'Signal Envelope');
```



Problem 5

```
clc;
fs = 1;
N = 1024;
dt = 1;
n = 0:1:N-1;
f0 = 0.1;
b = 0.175/(N-1);
sr = cos(2*pi*(f0 + 0.5.*n*b).*n);
[P, freqs, tout] = wigner(sr, fs);
imagesc(tout, freqs, P)
axis xy
colorbar
xlabel('Time')
ylabel('Frequency')
title('Wigner Implementation')
```

```
function [P, freqs, t] = wigner(S,fs)
  L = 2*ceil(length(S)/2);
  P = zeros(L,2*L);
  N = linspace(0,L,L);
  Nq = linspace(0,L,2*L);
  S = interp1(N,S,Nq,'linear');
  freqs = linspace(0,fs/2,L);
  dt = 1/(2*fs);
  t = [0:2*L-1]*fs/2;
```

```
for n = 1:length(t)
    m = [-(n-1):(n-1)];
    del = abs(m) + n > length(t);
    m(del) = [];
    ind1 = n + m;
    ind2 = n - m;
    mult = S(ind1).*conj(S(ind2));
    expmult = -4*1i*pi*dt.*m;
    for f = 1:length(freqs)
      P(f, n) =
2*dt*sum(mult.*exp(freqs(f).*expmult));
    end
  end
  P = real(P);
  freqs = freqs';
  t = t';
end
```