Q2 e)

Impulse and Step Responses

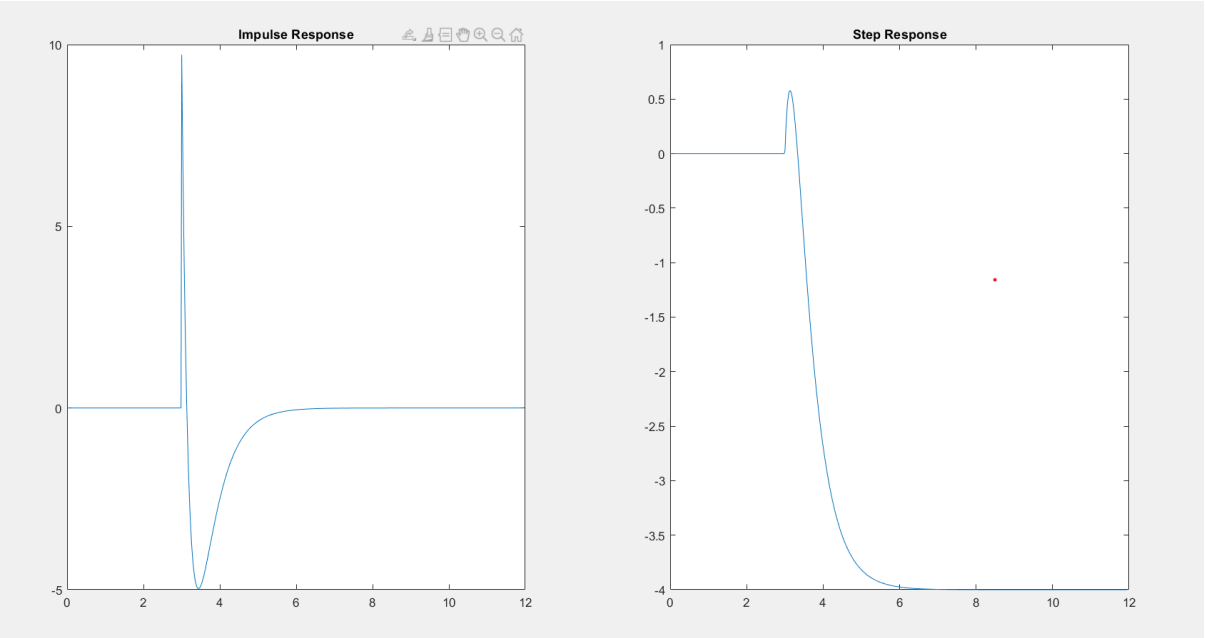

Figure 1: Impulse and Step responses

Large time response

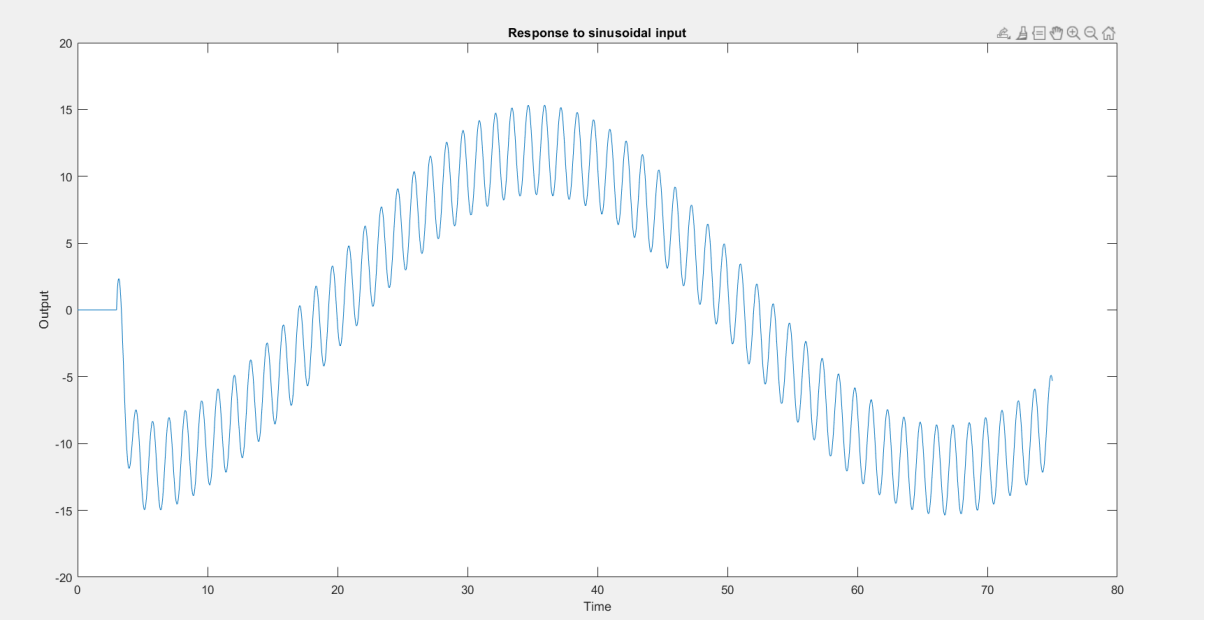

Figure 2: Large time response from lsim

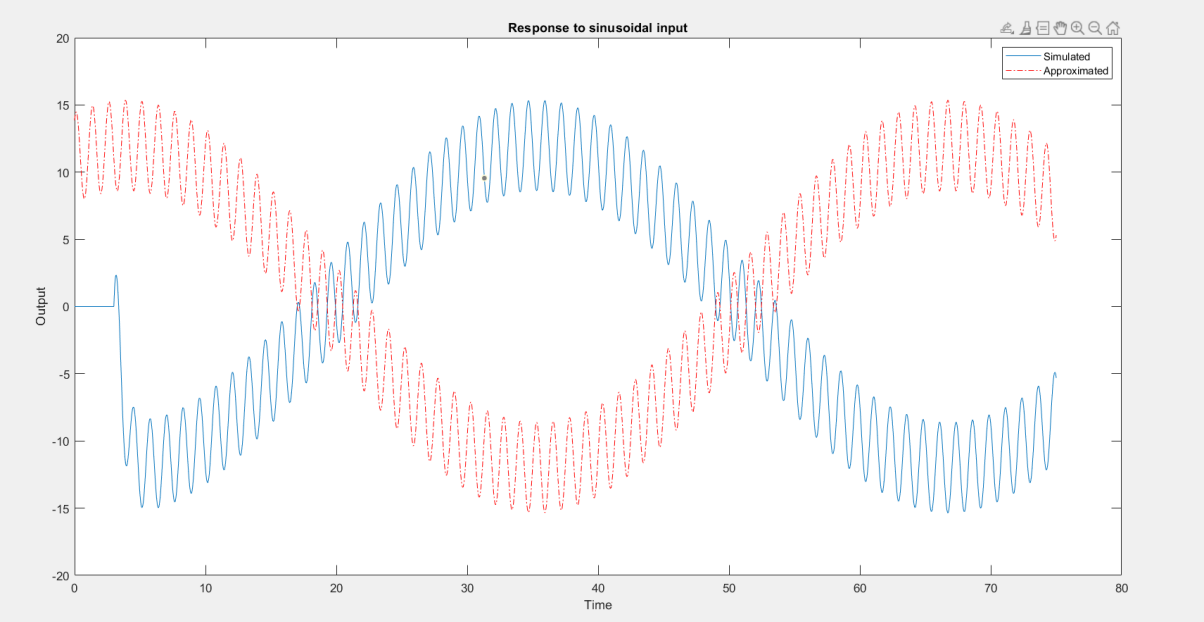

Figure 3: lsim compared to handwritten approximation

We see there is almost a 180 degree phase shift of the larger sinusoid. I am not sure whether that is a problem with my code or a problem with my derived expression. (or should they not match at all for small times?)

Bode Diagram

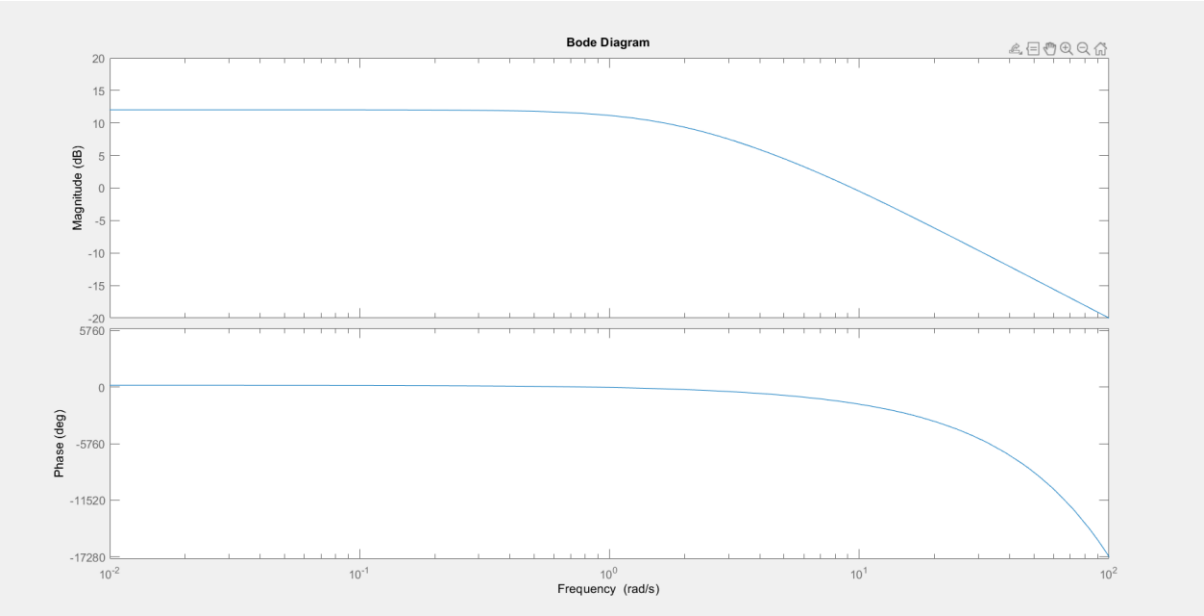

Figure 4: Bode Diagram of the system

Minimal system

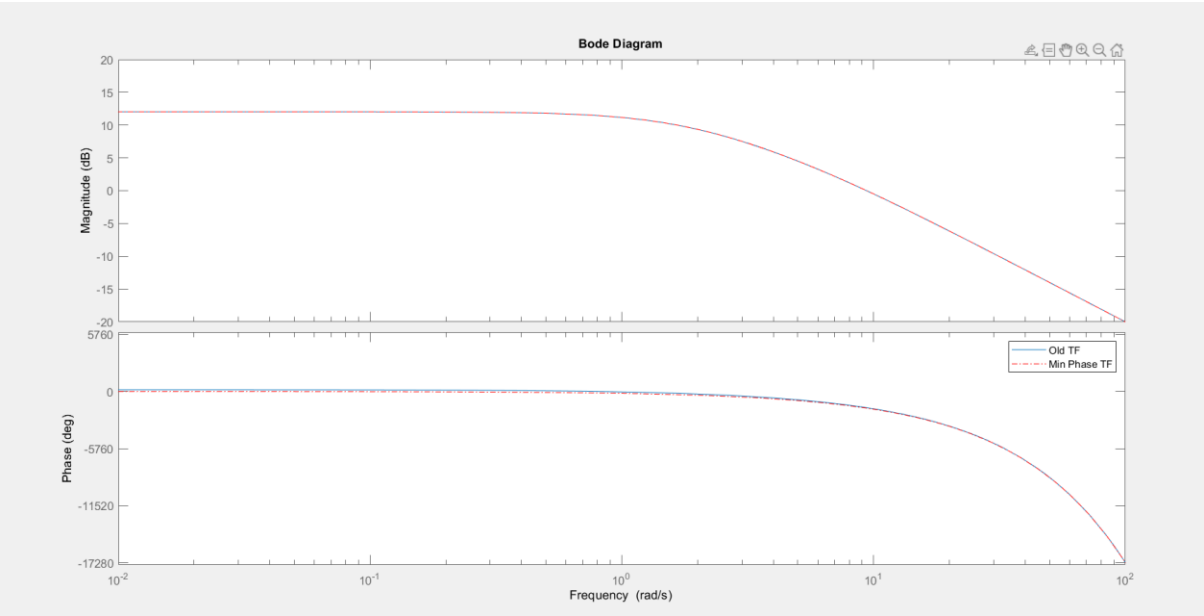

Figure 5: Comparing the bode diagrams of original system and minimal system

We can see that their magnitudes are same but the minimal system has lower phase than the original system. In fact, it will have the lowest phase among all systems having the same magnitudes.

MATLAB code

```
close all; clear;
G = tf([10 -40],[1 7 10],'InputDelay',3);
%% Part a)- Impulse and Step responses
% Impulse response
[Yimpulse,Timpulse] = impulse(G);
subplot(1,2,1);
plot(Timpulse,Yimpulse);
title('Impulse Response');
% Step response
[Ystep,Tstep] = step(G);
subplot(1,2,2);
plot(Tstep,Ystep);
title('Step Response');
%% Part b)-Response to the given sinusoidal input
Tmax = 75;
t = 0:0.01:Tmax;
U = 2*sin(5*t) + 3*cos(0.1*t);
Y = lsim(G,U,t);
yhand = 3.363*sin(5*t-17.87) + 11.9863*cos(0.1*t-0.3949);
figure();
plot(t,Y); title('Response to sinusoidal input');
xlabel('Time');ylabel('Output');
figure();
plot(t,Y,t,yhand,'r-.');
legend('Simulated','Approximated'); title('Response to sinusoidal input');
xlabel('Time');ylabel('Output');
%% Part c) Bode Plot
```

```
figure();
bode(G);
[MAG,PHASE,W] = bode(G);
%% Part d) MinPhase
G2 = tf([10 40],[1 7 10],'InputDelay',3);
[MAG2,PHASE2,W2] = bode(G2);
figure();
bode(G);
hold on;
bode(G2,'r-.');
legend('Old TF','Min Phase TF');
```