ECE 414 Homework #2 Redo - Josh Andrews

Table of Contents

Question 1

Analyze standard second order H(s) for Wn=100 and for Z=0.1, 0.5, and 0.9. Plot the step response.

Clean everything up before we start

```
clear;
clc;
```

First Set Wn to initial value of 100

```
Wn = 100;
```

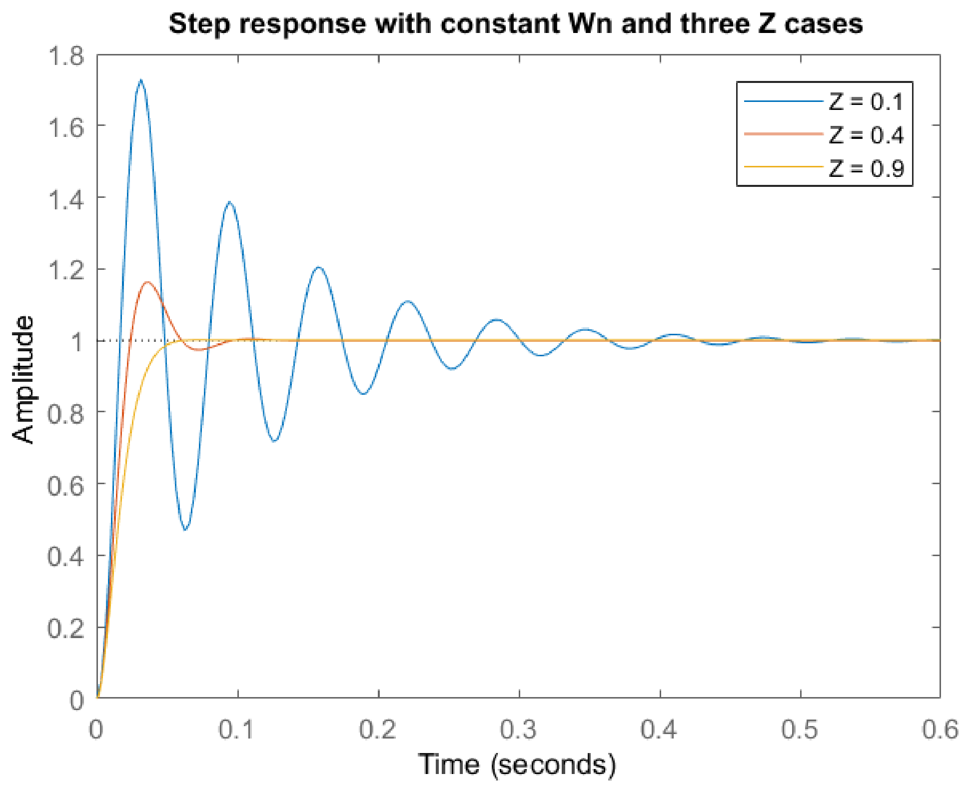
Now find the transfer function of H(s) for each Z by using a while loop. Also in the while loop plot the step response for each Z, set initially to 0.1

Also store the step response info for each Z

```
Z = 0.1;
i = 1;   % index variable for stepinfo
figure(1); clf;

while Z <= 0.9
    H=tf(Wn.^2, [1 2*Z*Wn Wn.^2]);
    Hinfo(i) = stepinfo(H);
    step(H);
    hold on;
    Z = Z + 0.4; % increment Z
    i = i + 1;
end

legend('Z = 0.1', 'Z = 0.4','Z = 0.9');
title('Step response with constant Wn and three Z cases');
```



Now compare the three cases using both the plot above and the step info for each of the three cases shown below

Z = 0.1

```
disp(Hinfo(1));
```

```
        RiseTime: 0.0113
    SettlingTime: 0.3837
     SettlingMin: 0.4685
     SettlingMax: 1.7292
       Overshoot: 72.9156
      Undershoot: 0
            Peak: 1.7292
        PeakTime: 0.0314
```

Z = 0.5

```
disp(Hinfo(2));
```

```
        RiseTime: 0.0164
    SettlingTime: 0.0808
     SettlingMin: 0.9315
     SettlingMax: 1.1629
       Overshoot: 16.2929
      Undershoot: 0
```

```
           Peak: 1.1629
       PeakTime: 0.0359
```

Z = 0.9

```
disp(Hinfo(3));
```

```
       RiseTime: 0.0288
    SettlingTime: 0.0470
     SettlingMin: 0.9024
     SettlingMax: 1.0015
       Overshoot: 0.1524
      Undershoot: 0
            Peak: 1.0015
        PeakTime: 0.0721
```

If Wn is held constant and Z is varied, it alters all of the step response parameters. Rise Time and Peak Time are both directly proportional to Z while % Overshoot, Settling Time, and the Peak are inversly proportional. The Settling Max also appeared to be inversely proportional however the min seemed to follow a more parabolic curve.

Question 2

Using the same H(s) and constant Wn = 100, let 0.1<=Z<=0.9

```
Z = linspace(0.1,0.9,50);
s = 0.01;   % 1% settling time
```

Find the simulated and analytic rise time, settling time, and %overshoot

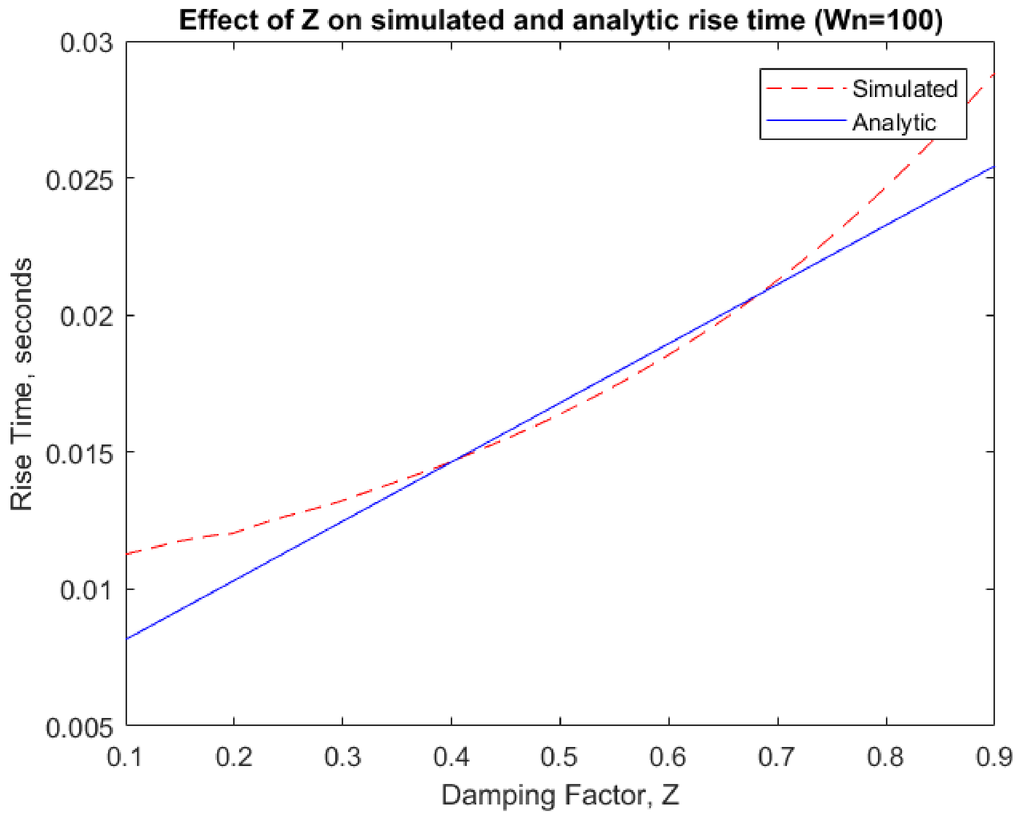
```
for i = 1:1:50
   H=tf(Wn.^2, [1 2*Z(i)*Wn Wn.^2]);
   Hinfo(i) = stepinfo(H);
   Rtime(i) = Hinfo(i).RiseTime;  %sim rise time
   Stime(i) = Hinfo(i).SettlingTime; % sim settling time
   Overshoot(i) = Hinfo(i).Overshoot;   %sim overshoot
   Rtime_calc(i) = (2.16 * Z(i) + 0.6)/Wn; %analytic rise time
   Stime_calc(i) = (-1*log(s*sqrt(1-(Z(i)^2))))/(Z(i)*Wn);
   Overshoot_calc(i) = 100*exp((-pi*Z(i))/(sqrt(1-Z(i)^2)));
end
```

Part A

Plot simulated and analytic rise time verses Z

```
figure(2);clf;
plot(Z, Rtime, '--r');
hold on;
plot(Z, Rtime_calc,'b');
legend('Simulated','Analytic');
```

```
xlabel('Damping Factor, Z');
ylabel('Rise Time, seconds');
title('Effect of Z on simulated and analytic rise time (Wn=100)');
```

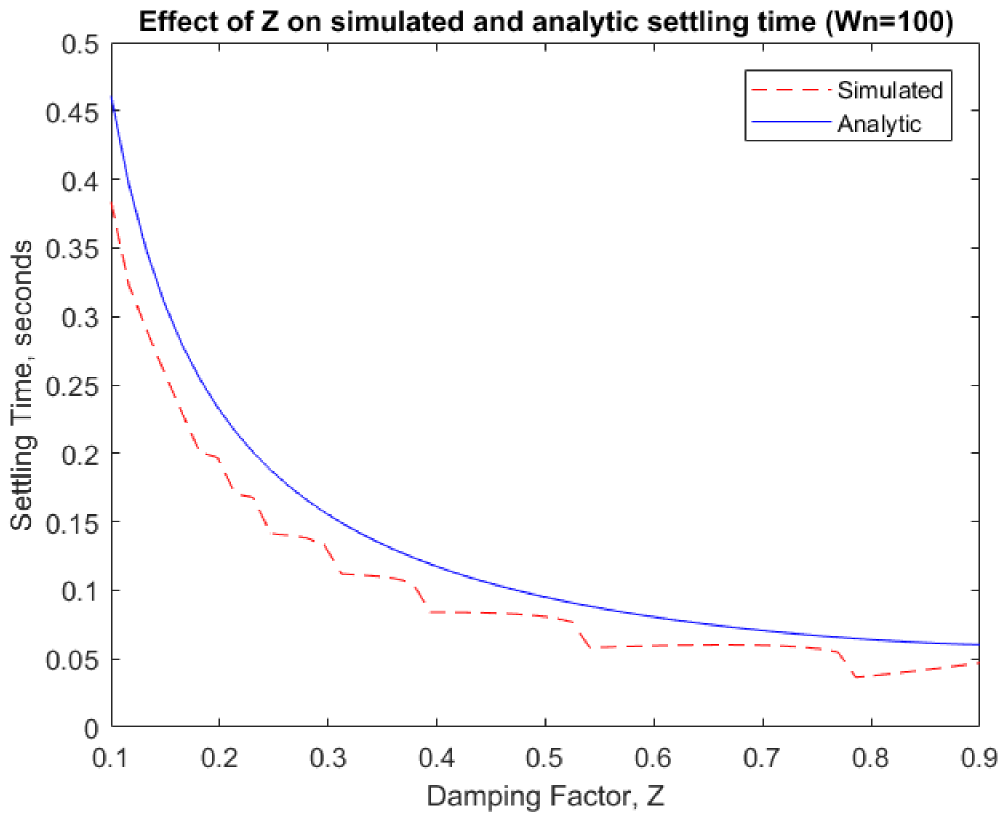


In the plot above it is shown that as Z increases so does the rise time of the step response. Both the simulated and analytic solutions are similar to one another however the most accurate range occurs when 0.4<=Z<=0.7 (approximately)

Part B

Plot simulated and analytic settling time versus Z

```
figure(3);clf;
plot(Z, Stime, '--r');
hold on;
plot(Z, Stime_calc,'b');
legend('Simulated','Analytic');
xlabel('Damping Factor, Z');
ylabel('Settling Time, seconds');
title('Effect of Z on simulated and analytic settling time (Wn=100)');
```

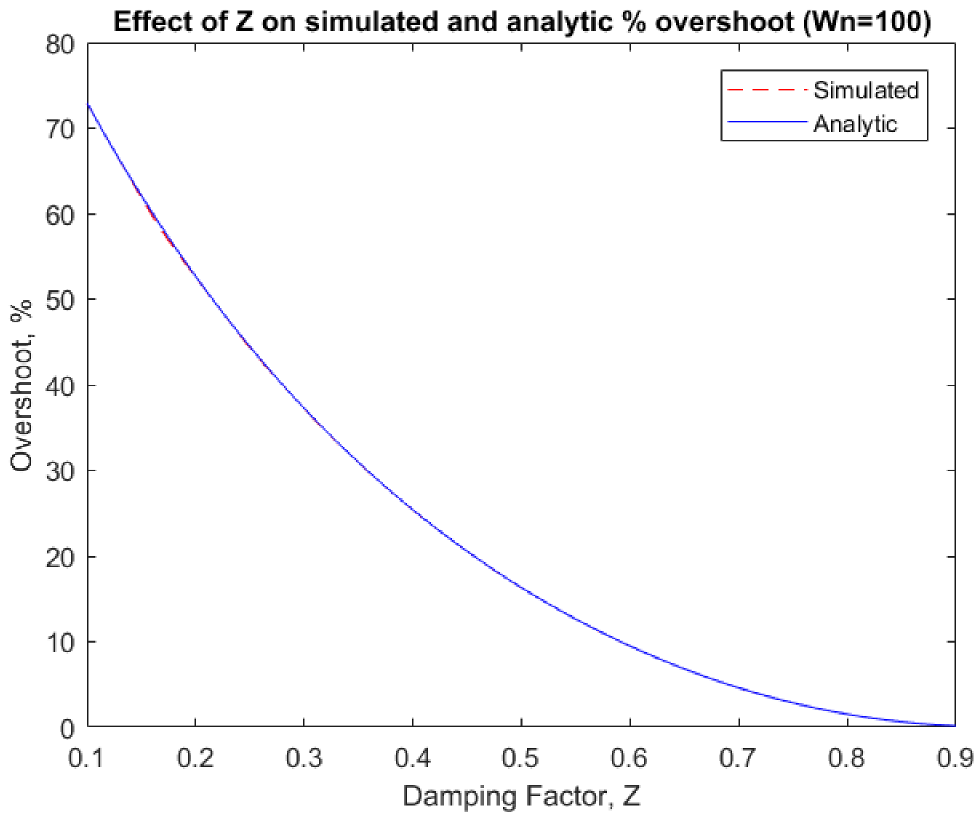


As the damping factor is increased the Settling time decreases in an exponential fashion. While both curves follow a similar shape, the analytic results are always greater than the simulated. The closest correlation occurs when 0.65<=Z<=0.75 (approximately)

Part C

Plot simulated and analytic overshoot versus Z

```
figure(4);clf;
plot(Z, Overshoot, '--r');
hold on;
plot(Z, Overshoot_calc,'b');
legend('Simulated','Analytic');
xlabel('Damping Factor, Z');
ylabel('Overshoot, %');
title('Effect of Z on simulated and analytic % overshoot (Wn=100)');
```



As seen in the plot above, as Z is increased, the %overshoot decreases. Both the analytic and simulated solutions to %overshoot are almost identical in the tested Z range. The only deviation occurs when Z is between 0.15 and 0.2, and that deviation is miniscule.

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