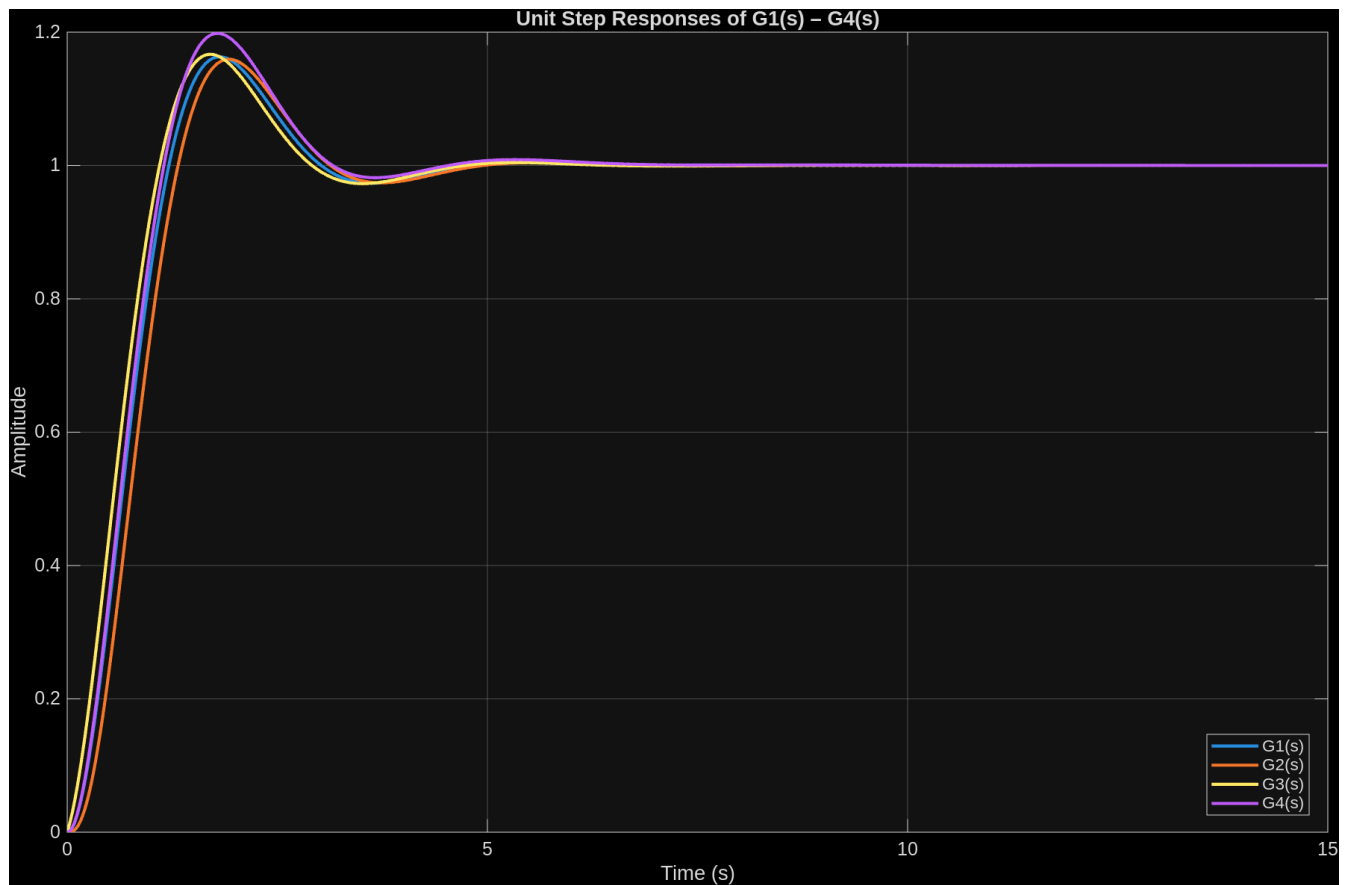# HW 6

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Problem 1

i

Figure 1: Step Responses

```
clc; clear; close all;
s = tf('s');

G1 = 4 / (s^2 + 2*s + 4);
G2 = 4 / ((s^2 + 2*s + 4) * (0.1*s + 1));
G3 = 4 * (0.1*s + 1) / (s^2 + 2*s + 4);
G4 = 4 * (2.1*s + 1) / ((s^2 + 2*s + 4) * (2*s + 1));

t = 0:0.01:15;
[y1, t1] = step(G1, t);
[y2, t2] = step(G2, t);
[y3, t3] = step(G3, t);
[y4, t4] = step(G4, t);
```

```
figure;
plot(t1, y1, 'LineWidth', 2); hold on;
plot(t2, y2, 'LineWidth', 2);
plot(t3, y3, 'LineWidth', 2);
plot(t4, y4, 'LineWidth', 2);
hold off;

grid on;
xlabel('Time (s)');
ylabel('Amplitude');
title('Unit Step Responses of G1(s) - G4(s)');
legend('G1(s)', 'G2(s)', 'G3(s)', 'G4(s)', 'Location', 'best');
set(gca, 'FontSize', 12);
```

ii

they all have the same second order denominator $s^2 + 2s + 4$

iii

$$\omega_n^2 = 4 \Rightarrow \omega_n = 2$$
$$2\zeta\omega_n = 2 \rightarrow \zeta = 0.5$$
$$\omega_d = \omega_n\sqrt{1 - \zeta^2} = 2\sqrt{1 - 0.25} = 1.73$$

therefore for $ G_1(s) $

$$\omega_d = 1.73$$
$$T_P = 1.81$$
$$\%OS = 16.3\%$$
$$T_s = 4$$

for $ G_2(2) $

$$T_P = 2$$
$$\%OS = 16.3\%$$
$$T_s = 4$$

for $ G_3(s) $

$$T_P = 1.7$$
$$\%OS = 20\%$$
$$T_s = 4$$

for $ G_4(s) $

$$T_P = 1.81$$
$$\%OS = 16.3\%$$
$$T_s = 4$$

each transfer function only changed one or two of the parameters and very subtly

2

i

$$
\begin{array}{c|ccc}
s^5 & 1 & 4 & 2 \\
s^4 & 4 & 5 & 2 \\
s^3 & \frac{11}{4} & \frac{3}{2} & 0 \\
s^2 & \frac{31}{11} & 2 & 0 \\
s^1 & -\frac{14}{31} & 0 & 0 \\
s^0 & 2 & 0 & 0 \\
\end{array}
$$