Total: ____/40

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Section: AB2

Question 1. ___/15

Theoretical/Experimental Results ___/5

*M_p = (MaxValue – SteadyState)/SteadyState * 100*

ζ	M_p Theory %	M_p Expmt %	t_r Theory (s)	t_r Expmt (s)	t_s Theory (s)	t_s Expmt (s)
2.0	0.00	0.00	8.20	8.02	11.60	11.14
1.5	0.00	0.00	5.85	5.80	8.30	8.32
1.0	0.00	0.10	3.35	3.32	5.00	4.76
0.8	1.52	1.77	2.50	2.54	3.68	3.38
0.7	4.60	5.62	2.16	2.28	3.02	4.86
0.5	16.30	17.24	1.62	2.04	6.28	5.32
0.3	37.23	40.37	1.30	1.88	10.14	10.62
0.2	52.66	70.56	1.21	1.86	15.08	17.46

Table 1: Theoretical/Experimental Results

Attach one sample plot from your StepResponseMetrics file that shows how you obtained the experimental results for one of the values of ζ.

Comparison of Theoretical vs. Experimental Results ___/5

Hint: Does it look like the theoretical equations on page 11 of the lab manual match the experimental values?

Put Discussion Here

Yes, they match.

Discussion of variation with ζ of M_p, t_s, t_r ___/5

Put Discussion Here

When ζ decreases, Mp increases, tr decreases, and ts first decreases and then increases.

Question 2. ___/15

Effect of ζ on Pole Locations (Derive Equation and Explain) ___/5

Put Discussion of ζ's Effect Here. Include the equation of the two pole locations in terms of ζ (you may assume $\omega_n = 1$). Include either a sketch/graph of the pole locations as ζ increases, or a description of what this graph would look like.

$$s_{1,2} = -\zeta \pm j\sqrt{1-\zeta^2}$$

As ζ increases, the poles go more left on the left half of the unit circle, and then go left on the x axis.

Effect of Pole Locations on M_p, t_s, t_r for an Underdamped System ___/5

Hint: An underdamped system has ζ ____
As ζ increases, the poles do____ which makes M_p, t_s, t_r do _______
(Double Hint: moving the poles causes two different effects on t_s)

An underdamped system has ζ less than 1.
As ζ increases, the poles go left on the left half of unit circle, which makes Mp smaller, ts smaller and tr greater

Effect of Pole Locations on M_p, t_s, t_r for an Overdamped/Critically Damped System ___/5

Hint: An over-damped system has ζ ____
A critically damped system has ζ ____
As ζ increases, the poles do____ which makes M_p, t_s, t_r do _______

An overdamped system has ζ greater than 1.
As ζ increases, the poles go left on the x axis, which makes Mp be zero, ts greater and tr greater

Question 3. ___/10

Investigate the effects of approximating an overdamped 2nd order system with a 1st order system. The approximation will be done by using a transfer function with only the pole that is closer to the origin, p_{min}.

$$H_1(s) = \frac{p_1 p_2}{(s+p_1)(s+p_2)} \quad \Rightarrow \quad H_2(s) = \frac{p_{\min}}{s+p_{\min}}$$

The response speed would be underestimated. The settling time would be overestimated. The rise time would be underestimated. And the overshoot would be overestimated.

Similarities/Differences on Overdamped 2nd-Order system to a 1st-Order System with the less negative of the 2nd-Order's poles ___/6

Plot the step responses for the 2nd order systems and their 1st order approximations for $\zeta = 1.5$, $\zeta = 5$, and $\zeta = 40$. Assume $\omega_n = 1$. How are the step responses of the 1st order approximations similar to and different from the step responses of the original 2nd order systems?

The 1st approximations' step responses have a similar shape as the original ones'. But they rise faster.

Effect of magnitude of ζ on the accuracy of the approximations ___/4

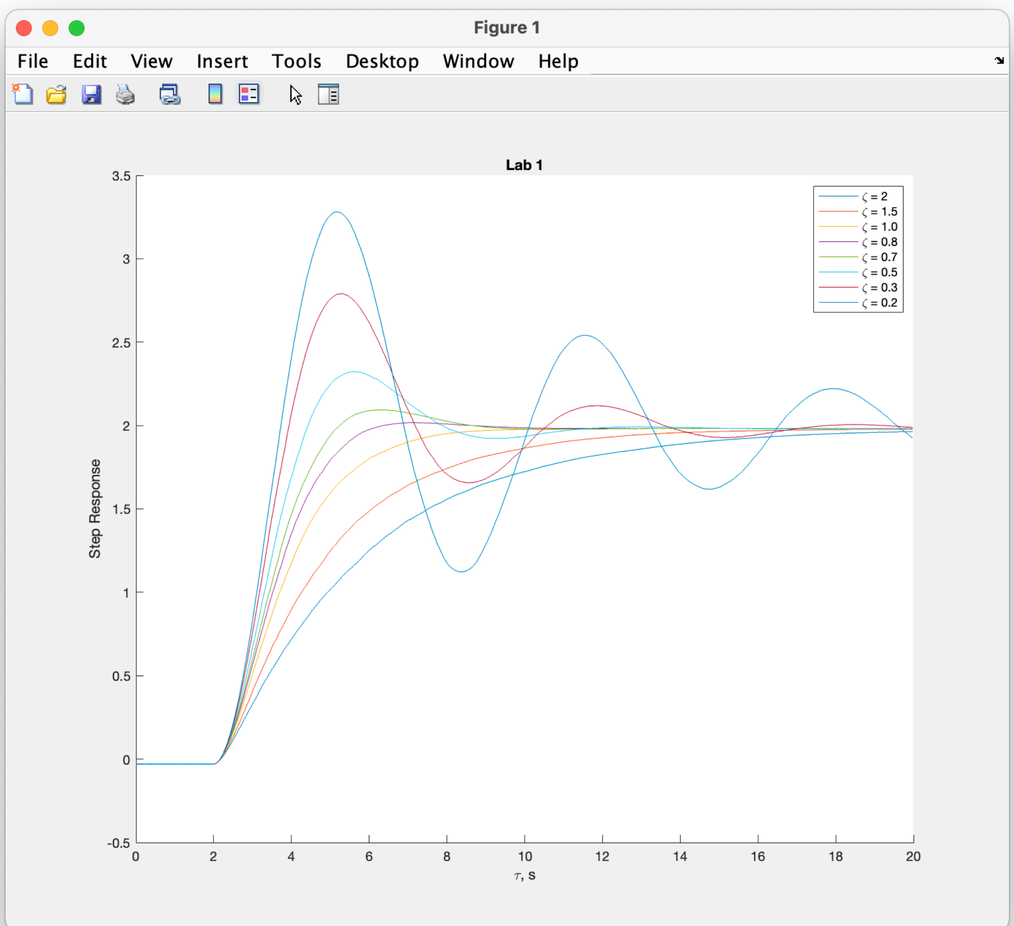
How does ζ affect the accuracy of the 1st order approximations?

The greater ζ is, the higher the accuracy is.

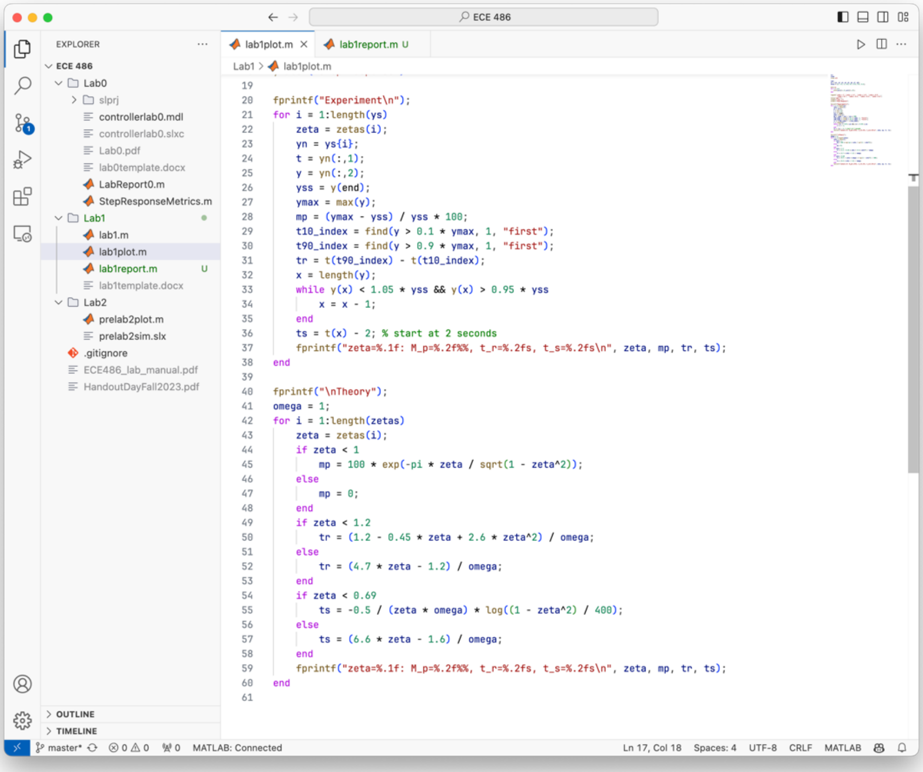
Attachments (3)

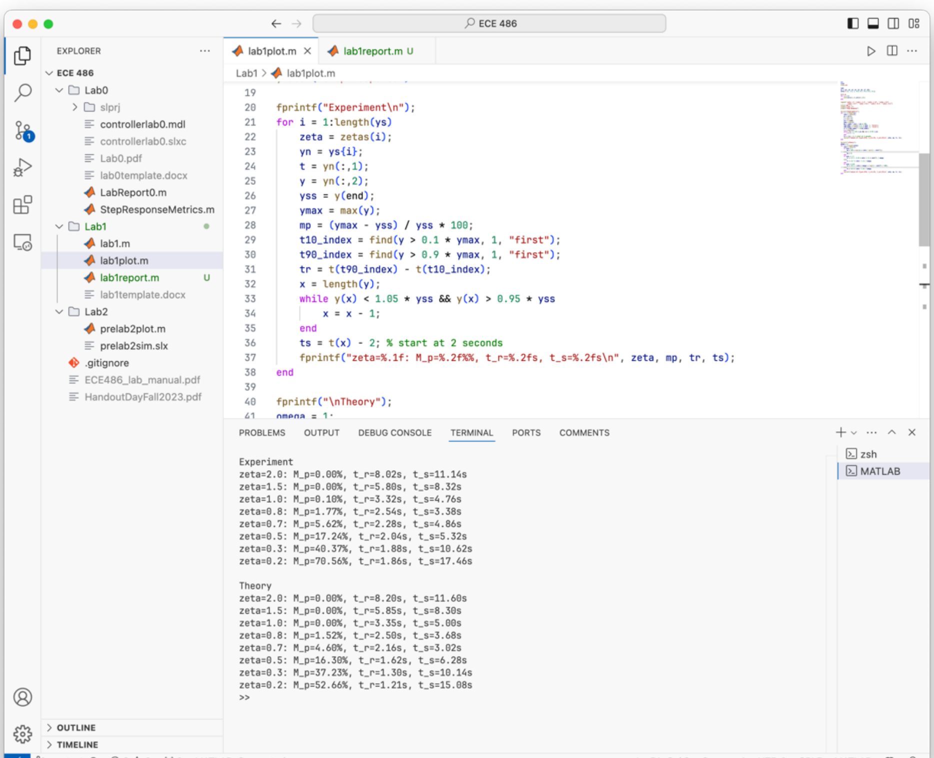
- Plots obtained during lab
- Sample response with relevant points for calculating M_p, t_s and t_r marked
- Step Responses comparing 2nd order systems and 1st order approximations

Plots obtained during lab:



Sample response with relevant points for calculating M_p, t_s and t_r marked:





Step Responses comparing 2nd order systems and 1st order