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### Total: \_\_\_\_/40

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Section: AB2

## Question 1. \_\_\_/15

### Theoretical/Experimental Results \_\_\_/5

*Mp = (MaxValue – SteadyState)/SteadyState \* 100*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ζ | M­p Theory % | M­p Expmt % | t­r Theory (s) | t­r Expmt (s) | t­s Theory (s) | t­s 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 Mp, ts, tr \_\_\_/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 ωn = 1). Include either a sketch/graph of the pole locations as ζ increases, or a description of what this graph would look like.*

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 Mp, ts, tr for an Underdamped System \_\_\_/5

*Hint: An underdamped system has ζ \_\_\_\_*

*As ζ increases, the poles do\_\_\_\_ which makes Mp, ts, tr do \_\_\_\_\_\_\_*

*(Double Hint: moving the poles causes two different effects on ts)*

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 Mp, ts, tr 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 Mp, ts, tr 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, pmin.*



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 ζ = 1.5, ζ = 5, and ζ = 40. Assume ωn = 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 Mp, ts and tr marked
* Step Responses comparing 2nd order systems and 1st order approximations

Plots obtained during lab:

A screenshot of a computer

Description automatically generated

Sample response with relevant points for calculating Mp, ts and tr marked: A screenshot of a computer

Description automatically generated

A screenshot of a computer

Description automatically generated

Step Responses comparing 2nd order systems and 1st order A screen shot of a computer

Description automatically generated