ME7120 PROJECT 3

WRIGHT STATE UNIVERSITY

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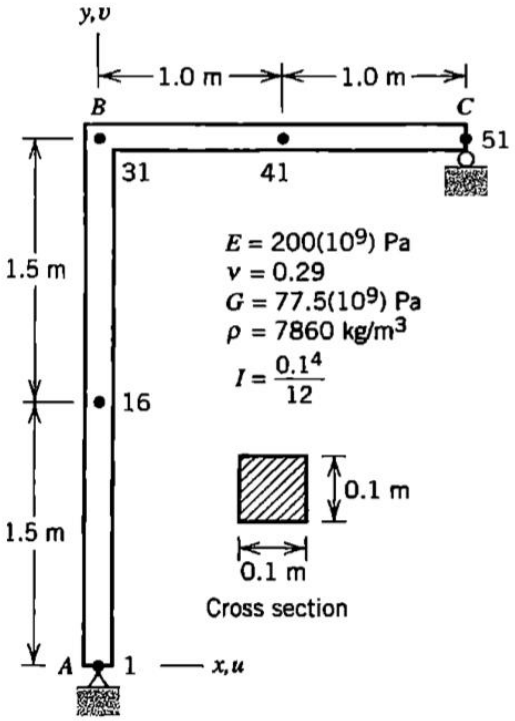
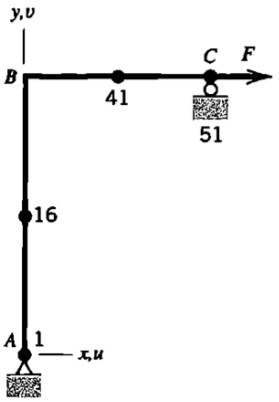
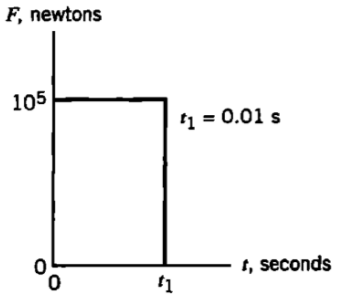
PROBLEM STATEMENT

Problem Statement

- Program the Newmark beta method and apply it to the geometry shown in Figure 11.17-1 subject to the loads of section 11.18.







PROBLEM STATEMENT

- Perform the comparison of all of the five Newmark beta methods shown in 11.13-1, similar to what is shown in figure 11.18-2 and table 11.18-1.

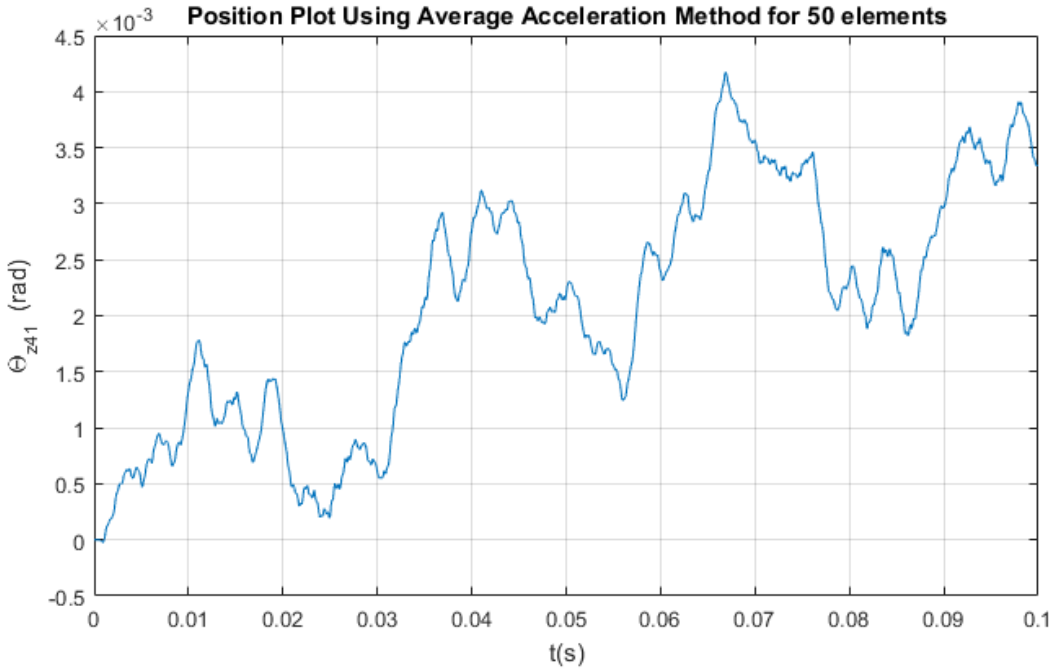
Table 1: Stability and Accuracy of Selected Implicit Direct Integration Methods

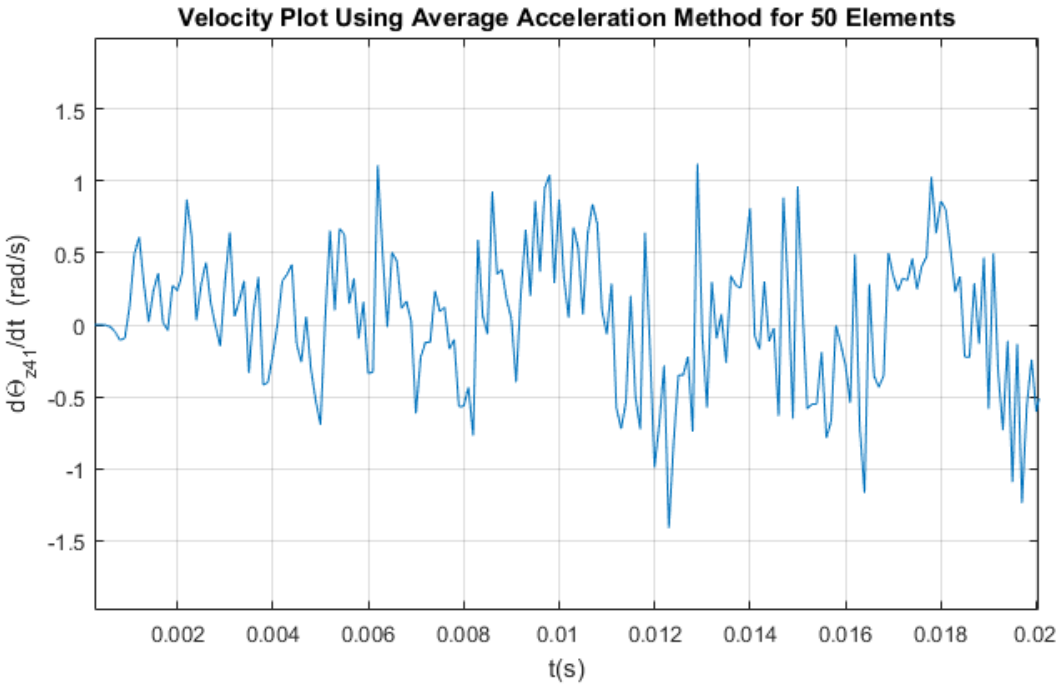
Version [or references]	γ	β	Stability condition	Error in $\{\mathbf{D}\}$ for $\xi = 0$
Newmark Methods				
Average acceleration	$\frac{1}{2}$	$\frac{1}{4}$	Unconditional	$O(\Delta t^2)$
Linear acceleration	$\frac{1}{2}$	$\frac{1}{6}$	$\Omega_{crit} = 3.464$ if $\xi = 0$	$O(\Delta t^2)$
Fox-Goodwin	$\frac{1}{2}$	$\frac{1}{12}$	$\Omega_{crit} = 2.449$ if $\xi = 0$	$O(\Delta t^4)$
Algorithmically damped	$\geq \frac{1}{2}$	$\geq \frac{1}{4}(\gamma + \frac{1}{2})^2$	Unconditional	$O(\Delta t)$
Hilber-Hughes-Taylor (α-method), $-\frac{1}{3} \leq \alpha \leq 0$				
[2.13,11.55]	$\frac{1}{2}(1 - 2\alpha)$	$\frac{1}{4}(1 - \alpha)^2$	Unconditional	$O(\Delta t^2)$

Results

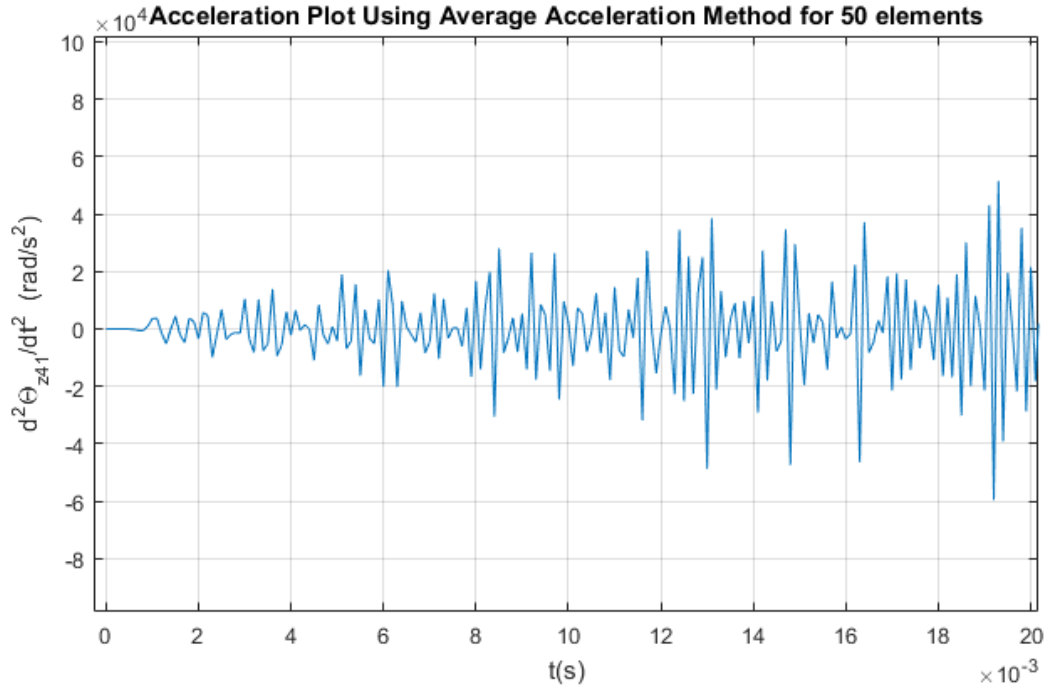
Method	γ	β	Δt	***Max Disp.***	***Max Vel.***	***Max Acc.***
Average Acceleration	0.5	0.25	0.0001	0.004176	1.548	82,310
Linear Acceleration	0.5	0.167	0.000001	0.004035	2.323	129,100
Fox-Goodwin	0.5	0.083	0.000001	0.004039	2.294	132,300
Algorithmically Damped	0.75	0.39062	0.0001	0.003839	0.5044	1,427
Hilber-Hughes-Taylor (α=-0.1)	0.6	0.3025	0.0001	0.003957	0.5906	2,379

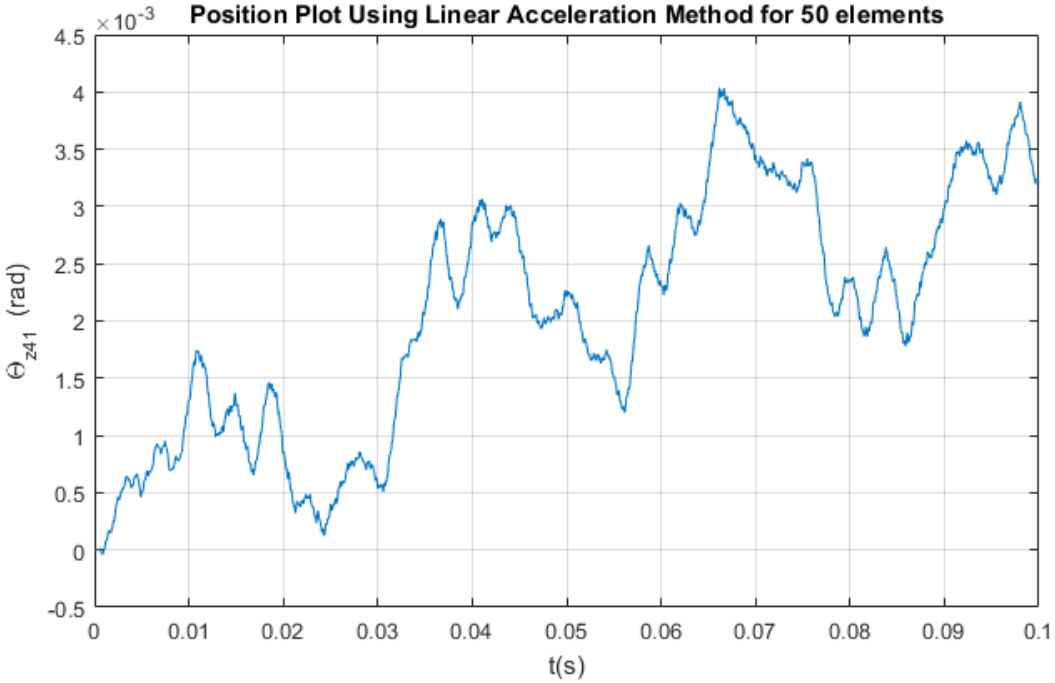
RESULTS


Position Plot Using Average Acceleration Method for 50 elements
×10^-3
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
Θz41 (rad)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
t(s)

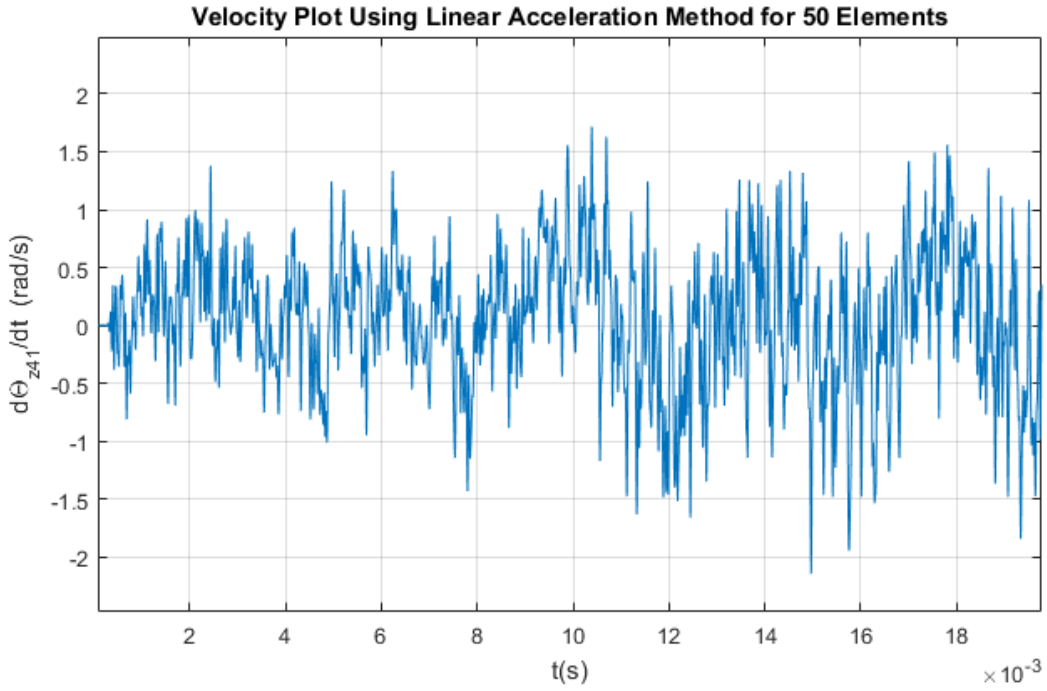

Velocity Plot Using Average Acceleration Method for 50 Elements
1.5
1
0.5
0
-0.5
-1
-1.5
dΘz41/dt (rad/s)
0.002
0.004
0.006
0.008
0.01
0.012
0.014
0.016
0.018
0.02
t(s)

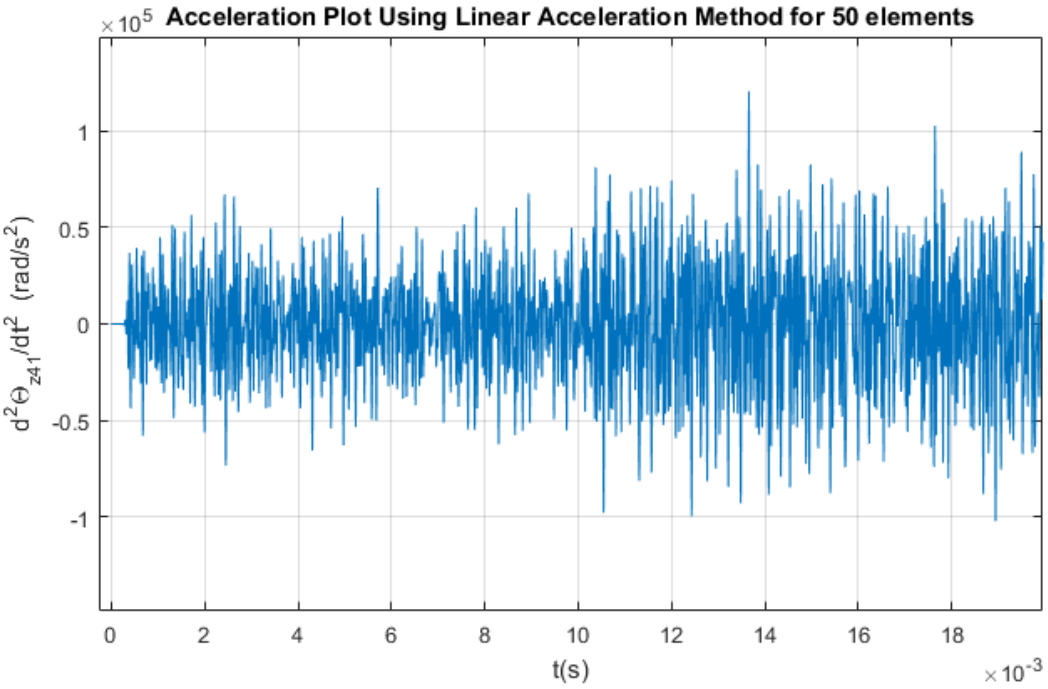
RESULTS


Acceleration Plot Using Average Acceleration Method for 50 elements
×10^4
d^2Θ_z41/dt^2 (rad/s^2)
t(s)
×10^-3

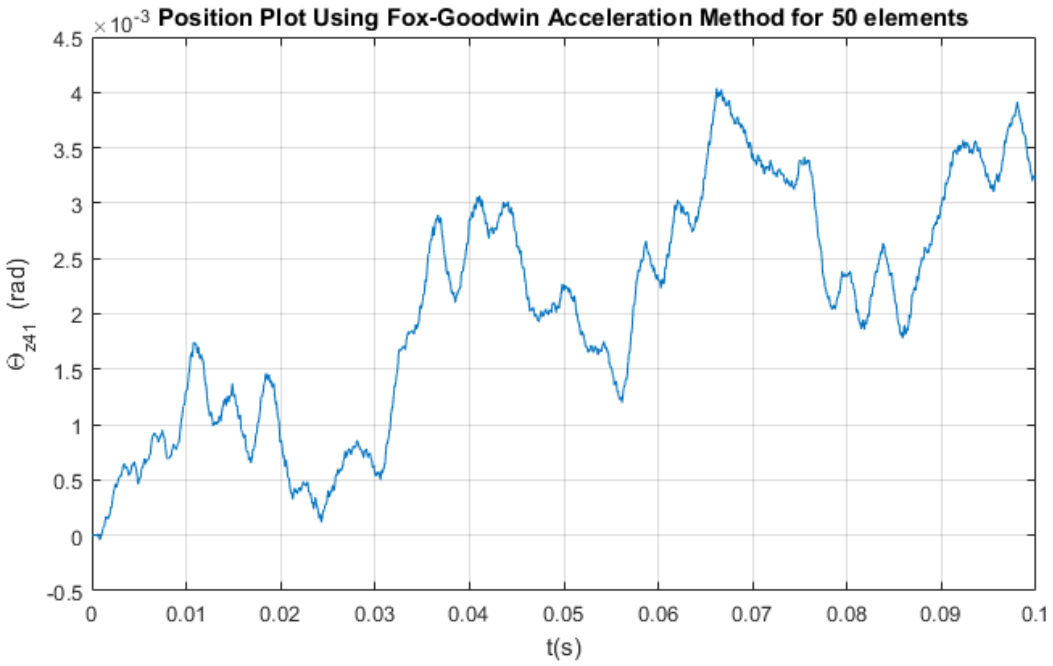

Position Plot Using Linear Acceleration Method for 50 elements
×10^-3
Θ_z41 (rad)
t(s)

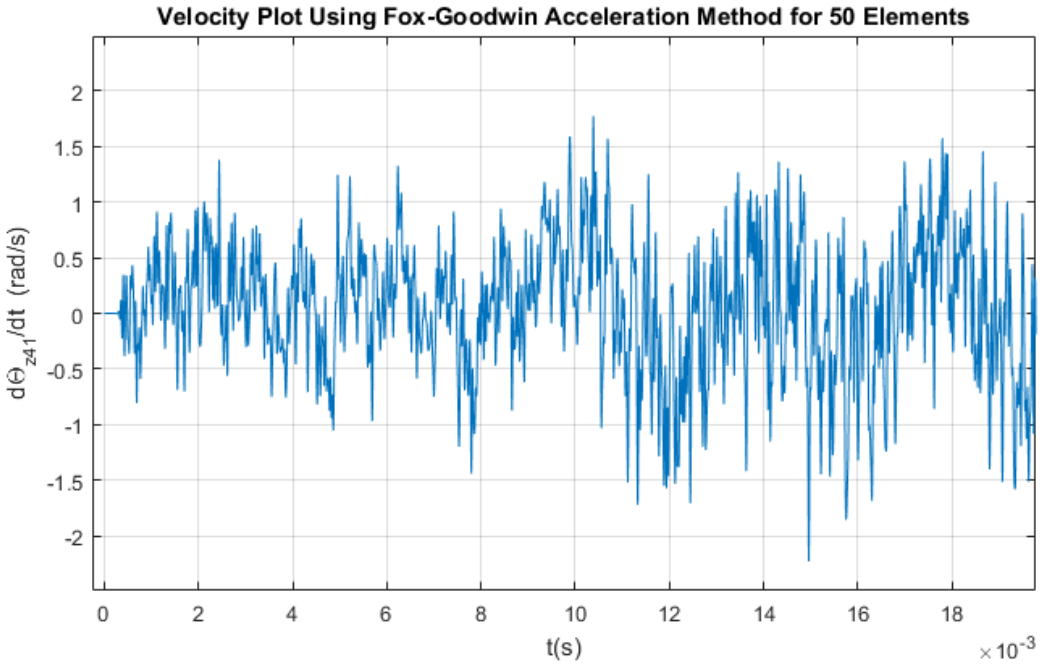
RESULTS


Velocity Plot Using Linear Acceleration Method for 50 Elements
dΘz41/dt (rad/s)
t(s)
×10-3

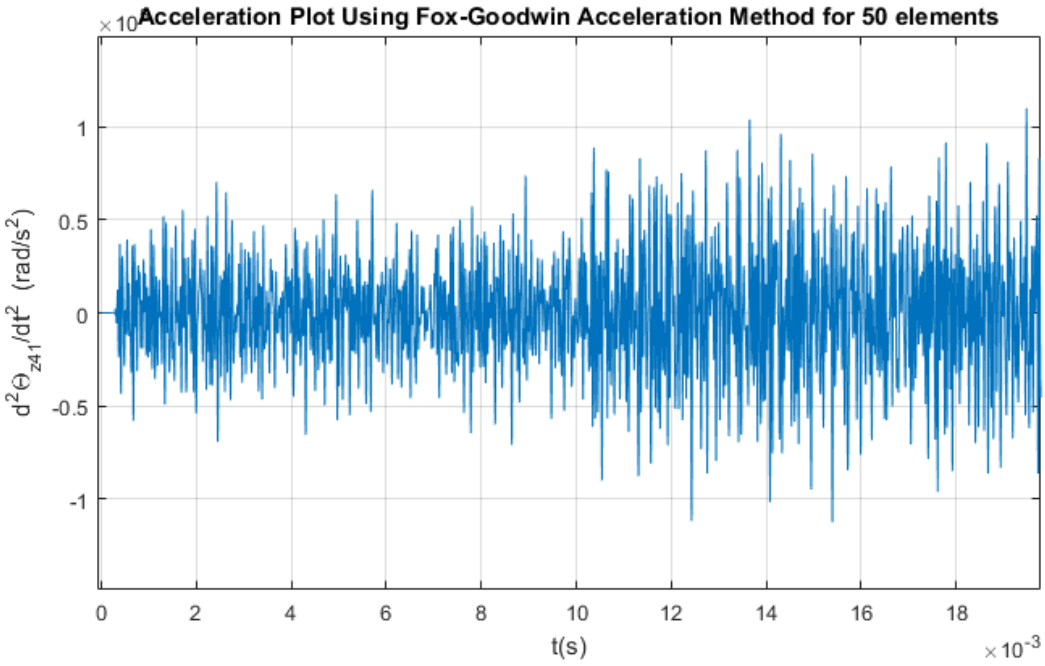

×10^5 Acceleration Plot Using Linear Acceleration Method for 50 elements
d2Θz41/dt2 (rad/s2)
t(s)
×10-3

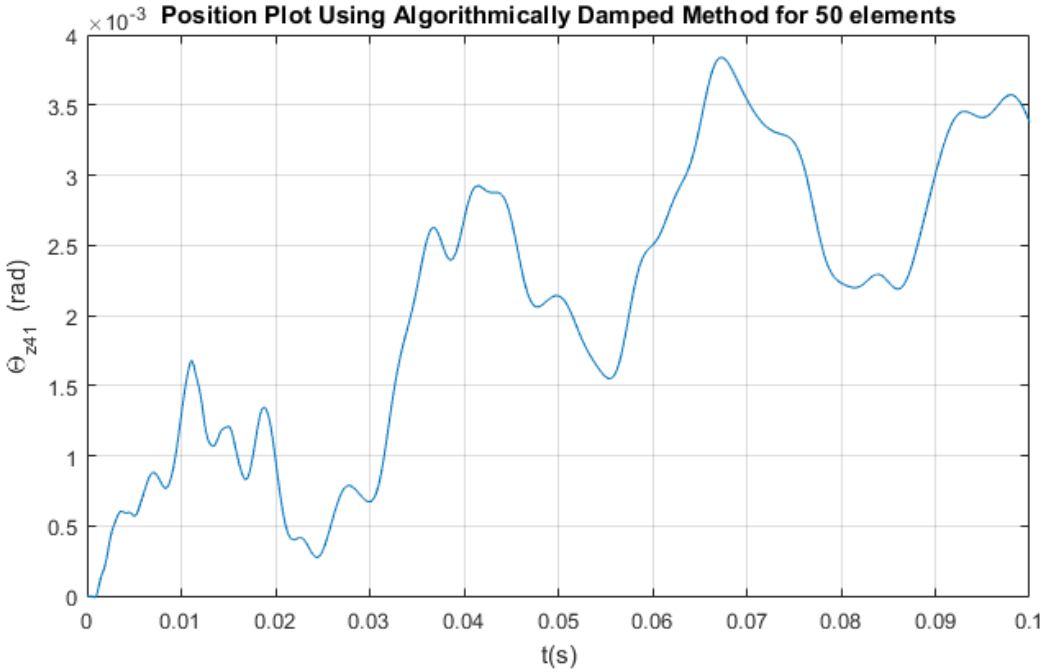
RESULTS


Position Plot Using Fox-Goodwin Acceleration Method for 50 elements
×10^-3
Θz41 (rad)
t(s)

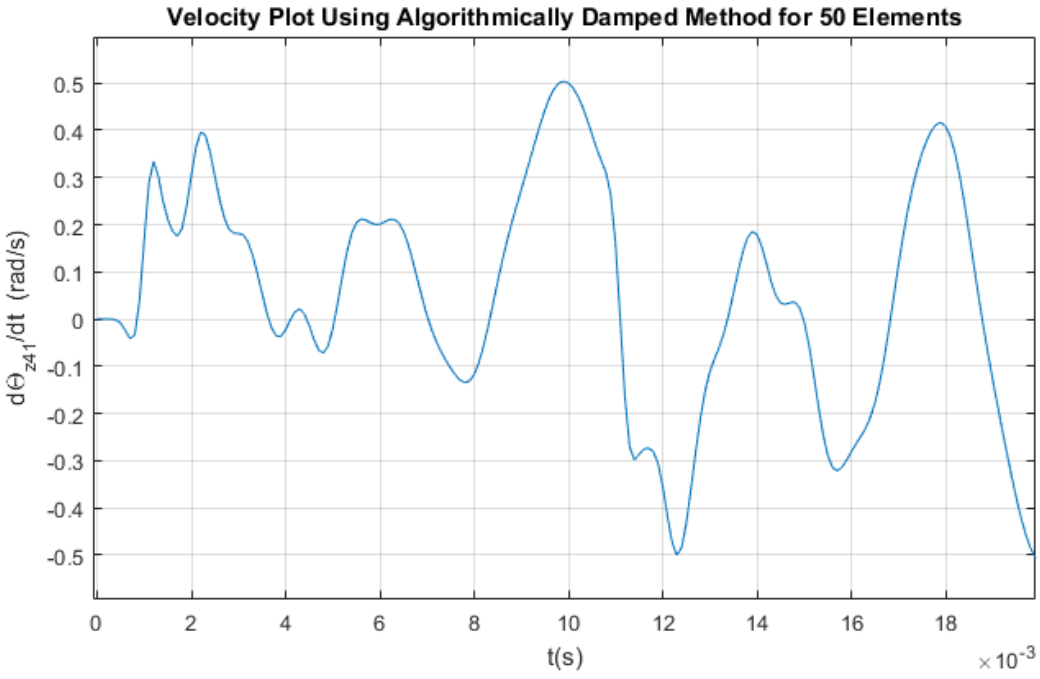

Velocity Plot Using Fox-Goodwin Acceleration Method for 50 Elements
dΘz41/dt (rad/s)
t(s)
×10^-3

RESULTS

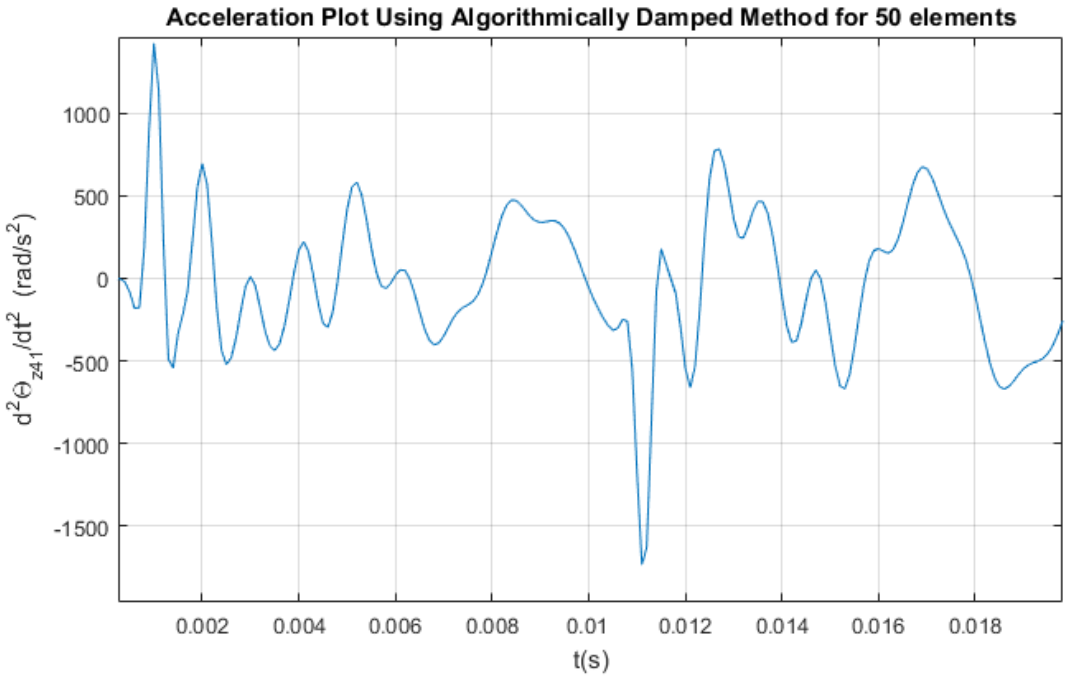

Acceleration Plot Using Fox-Goodwin Acceleration Method for 50 elements
×10
1
0.5
0
-0.5
-1
d²Θz41/dt² (rad/s²)
0
2
4
6
8
10
12
14
16
18
t(s)
×10-3

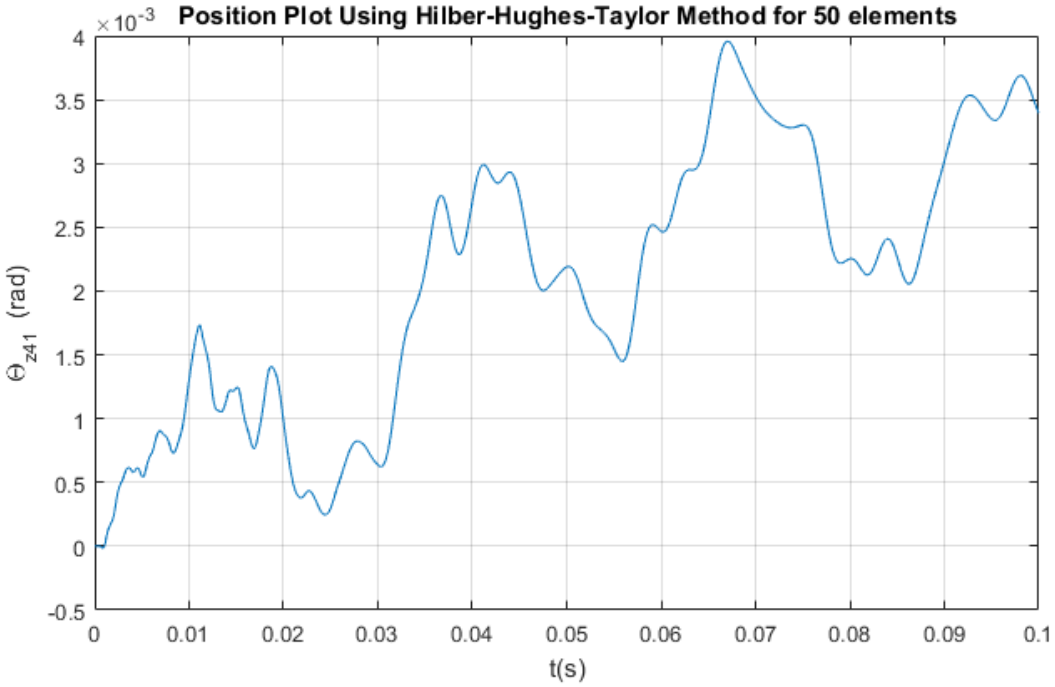

×10-3 Position Plot Using Algorithmically Damped Method for 50 elements
4
3.5
3
2.5
2
1.5
1
0.5
0
Θz41 (rad)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
t(s)

RESULTS

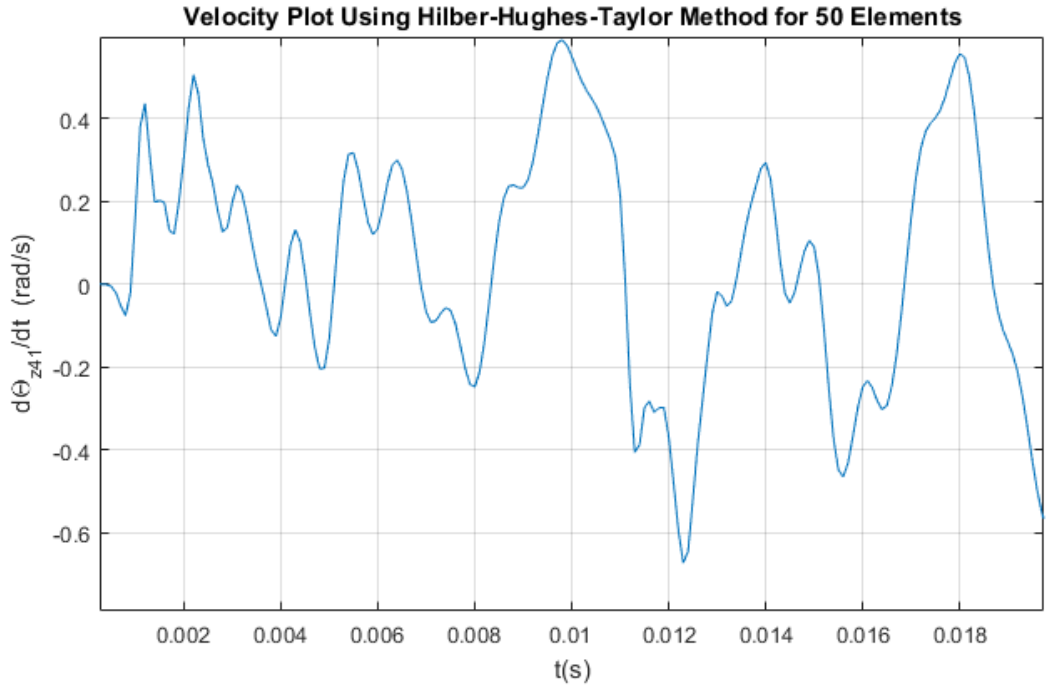

Velocity Plot Using Algorithmically Damped Method for 50 Elements
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
dΘz41/dt (rad/s)
0
2
4
6
8
10
12
14
16
18
t(s)
×10-3

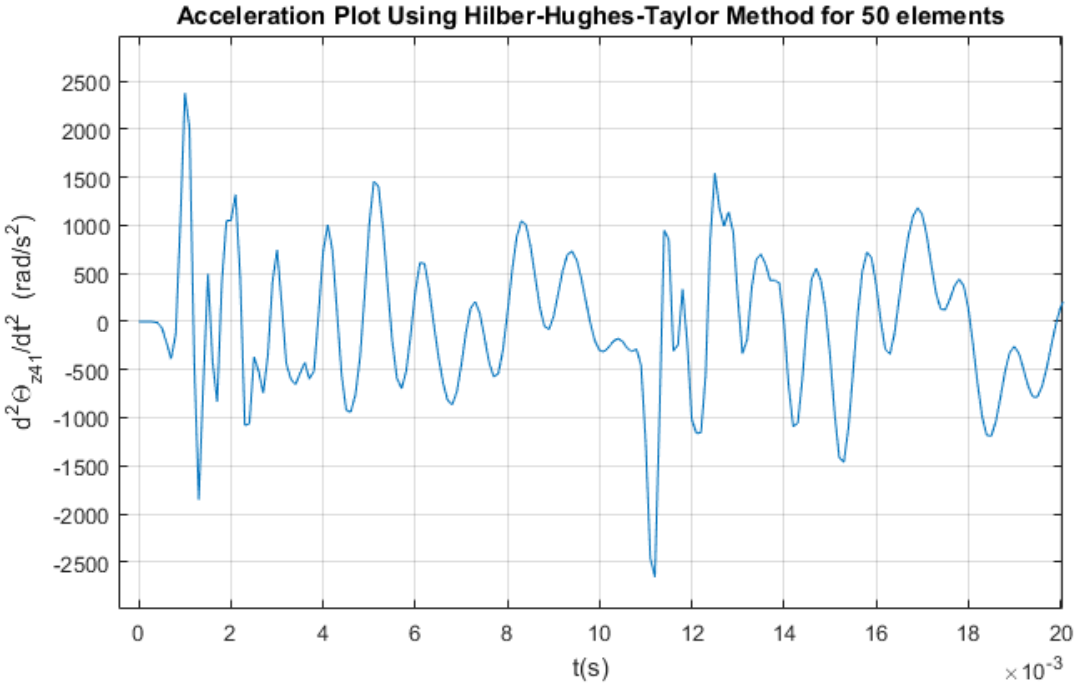
RESULTS


Acceleration Plot Using Algorithmically Damped Method for 50 elements
1000
500
0
-500
-1000
-1500
0.002
0.004
0.006
0.008
0.01
0.012
0.014
0.016
0.018
t(s)
d²Θz41/dt² (rad/s²)


Position Plot Using Hilber-Hughes-Taylor Method for 50 elements
×10⁻³
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
t(s)
Θz41 (rad)

RESULTS


Velocity Plot Using Hilber-Hughes-Taylor Method for 50 Elements
0.4
0.2
0
-0.2
-0.4
-0.6
0.002
0.004
0.006
0.008
0.01
0.012
0.014
0.016
0.018
t(s)


Acceleration Plot Using Hilber-Hughes-Taylor Method for 50 elements
2500
2000
1500
1000
500
0
-500
-1000
-1500
-2000
-2500
0
2
4
6
8
10
12
14
16
18
20
t(s)
×10-3

CONCLUSION

Conclusion

The five Newmark Beta Methods were used to analyze the dynamic behavior of the L-Frame shown in the problem statement above. All values for gamma and beta, that were used for the analysis, are shown in Table 1. The first three methods yielded similar results for the maximum displacement. However, the maximum velocity and acceleration increased as beta decreased. A smaller delta t was needed to create adequate plots on the Linear Acceleration and Fox-Goodwin method. The results from the Algorithmically Damped and Hilber-Hughes-Taylor method differed greatly when looking at the maximum velocity and acceleration. However, the maximum displacements stayed consistent between all five methods of Implicit Direct Integration.