Assignment 7

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Inputs

LFORM == 1 - TOTAL LAGRANGE, ELSE UPDATED LAGRANGE

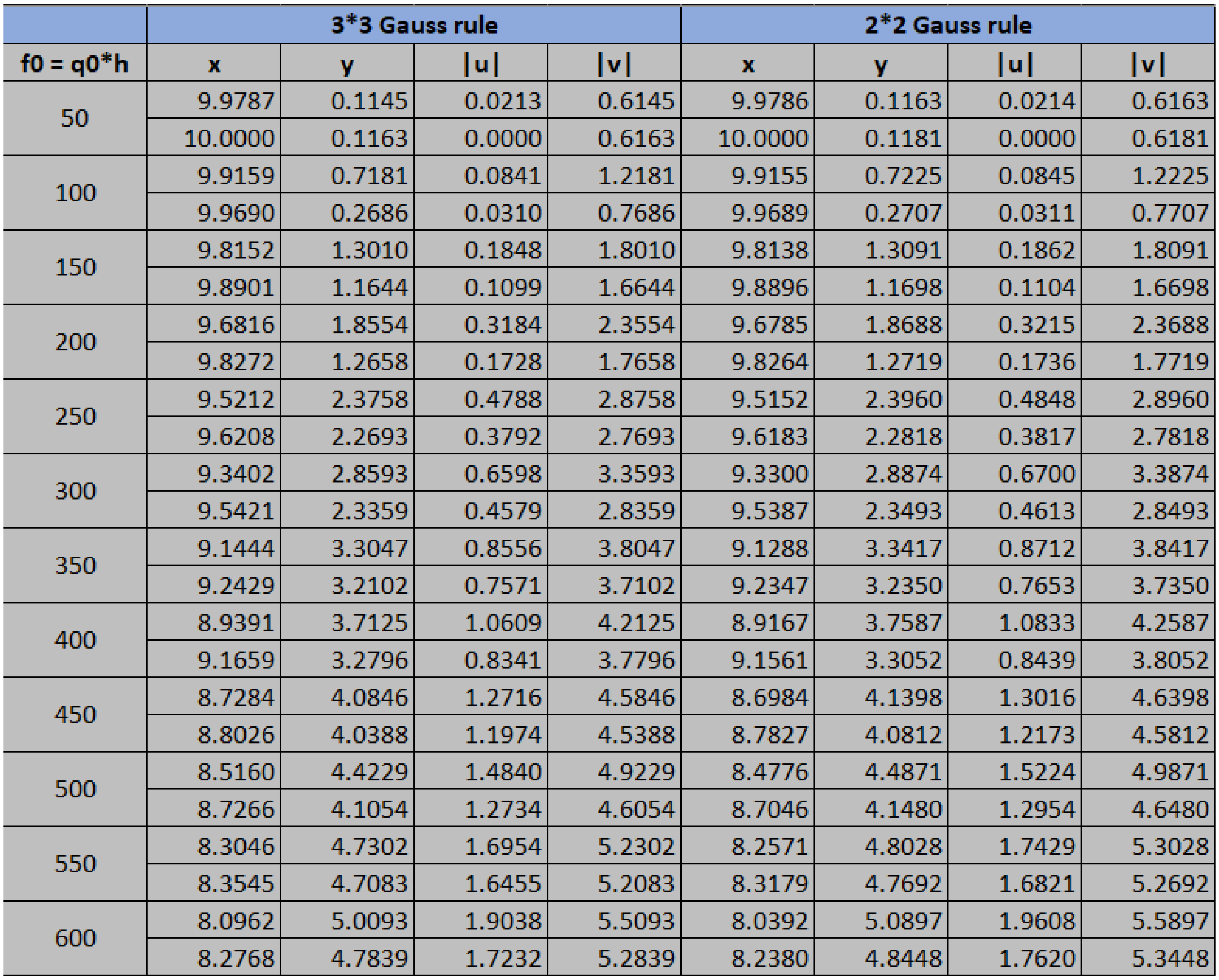
IGRAD = 1 - PERFORM POST-PROCESSING

MODEL = 1 - NO ITERATION, ELSE ITERATIONS

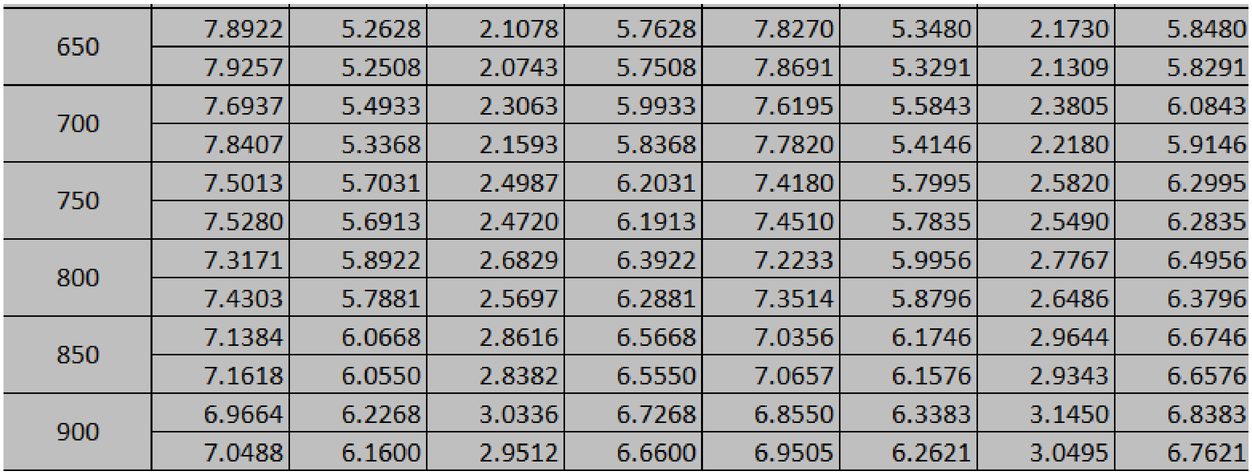
Parameters	**Value(s)**
Simulation Parameters	
ITERMAX	25
Epsilon	0.001
GAMA	0.5
LFORM	2
IGRAD	1
MODEL	2
Domain Inputs	
X0	0
Y0	0
x_length	10
y_length	1
thick	0.1
Mesh Inputs	
NX	5
NY	1
NPE	8
NDF	2
DX	(x_length/NX)*ones(NX,1)
DY	(y_length/NX)*ones(NY,1)
NGPF	3
Material Properties	
E	1.2E7
v	0.3
G	4.6154E6
Loading condition	
NLS	32
DPX	Zeros(NLS,1)
DPY	Zeros(NLS,1)
F	[0 0]
Essential Boundary Conditions	

NSPV	6
ISPV	[1,2; 1,1; 12,2; 12 ,1; 18,2; 18,1]
VSPV	[0 0 0 0 0 0]
Natural Boundary Conditions	
NSSV	20
ISSV	[19 2; 20 2; 21 2; 22 2; 23 2; 24 2; 25 2; 26 2; 27 2; 28 2; 2 2; 3 2; 4 2; 5 2; 6 2; 7 2; 8 2; 9 2; 10 2; 11 2]
VSSV	[0.066667 0.033333 0.066667 0.033333 0.066667 0.033333 0.066667 0.033333 0.066667 0.016667 0.066667 0.033333 0.066667 0.033333 0.066667 0.033333 0.066667 0.033333 0.066667 0.016667]

Tabular Results

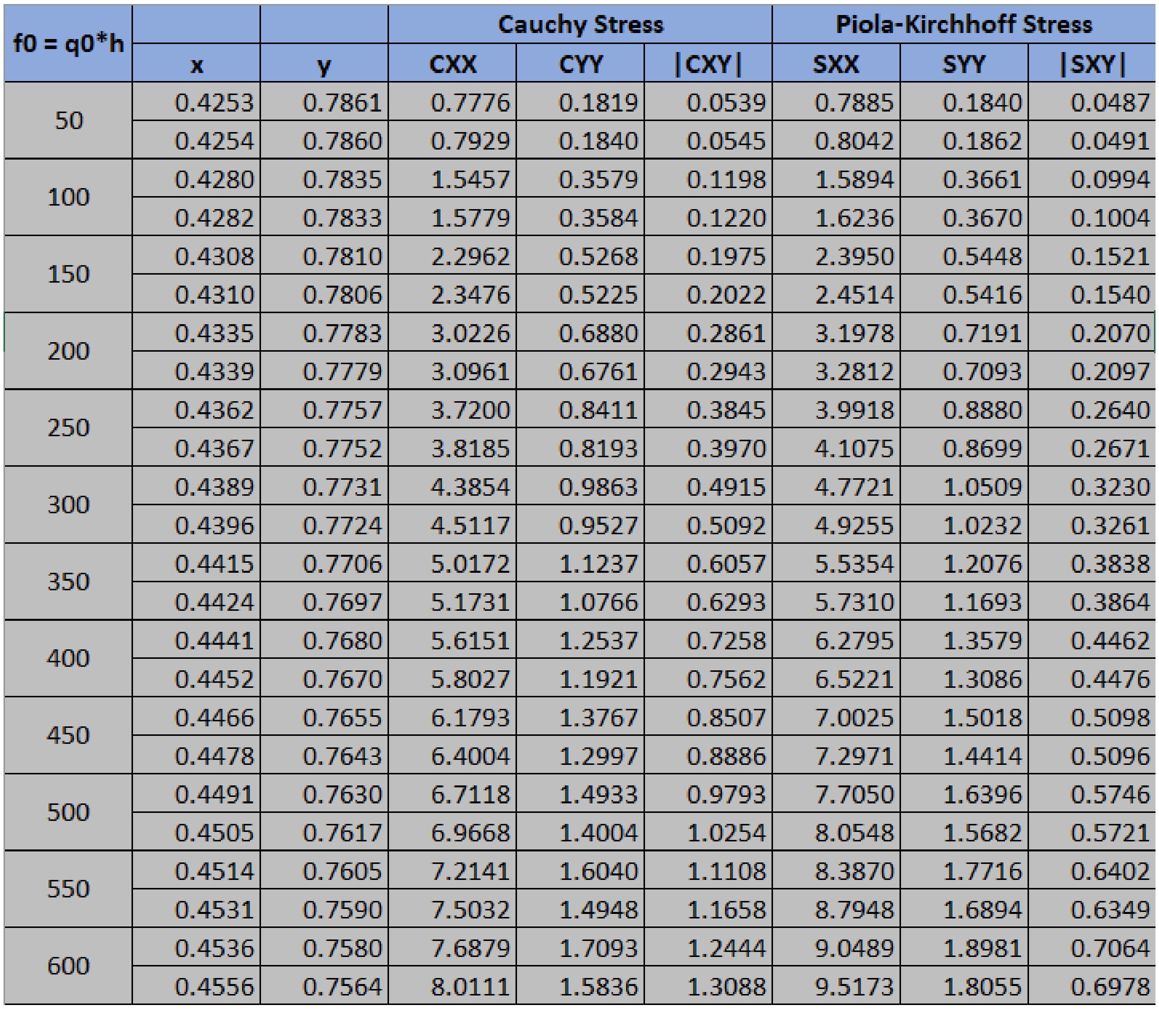


	3*3 Gauss rule				**2*2 Gauss rule**			
f0 = q0*h	**x**	**y**	**|u|**	**|v|**	**x**	**y**	**|u|**	**|v|**
50	9.9787	0.1145	0.0213	0.6145	9.9786	0.1163	0.0214	0.6163
	10.0000	0.1163	0.0000	0.6163	10.0000	0.1181	0.0000	0.6181
100	9.9159	0.7181	0.0841	1.2181	9.9155	0.7225	0.0845	1.2225
	9.9690	0.2686	0.0310	0.7686	9.9689	0.2707	0.0311	0.7707
150	9.8152	1.3010	0.1848	1.8010	9.8138	1.3091	0.1862	1.8091
	9.8901	1.1644	0.1099	1.6644	9.8896	1.1698	0.1104	1.6698
200	9.6816	1.8554	0.3184	2.3554	9.6785	1.8688	0.3215	2.3688
	9.8272	1.2658	0.1728	1.7658	9.8264	1.2719	0.1736	1.7719
250	9.5212	2.3758	0.4788	2.8758	9.5152	2.3960	0.4848	2.8960
	9.6208	2.2693	0.3792	2.7693	9.6183	2.2818	0.3817	2.7818
300	9.3402	2.8593	0.6598	3.3593	9.3300	2.8874	0.6700	3.3874
	9.5421	2.3359	0.4579	2.8359	9.5387	2.3493	0.4613	2.8493
350	9.1444	3.3047	0.8556	3.8047	9.1288	3.3417	0.8712	3.8417
	9.2429	3.2102	0.7571	3.7102	9.2347	3.2350	0.7653	3.7350
400	8.9391	3.7125	1.0609	4.2125	8.9167	3.7587	1.0833	4.2587
	9.1659	3.2796	0.8341	3.7796	9.1561	3.3052	0.8439	3.8052
450	8.7284	4.0846	1.2716	4.5846	8.6984	4.1398	1.3016	4.6398
	8.8026	4.0388	1.1974	4.5388	8.7827	4.0812	1.2173	4.5812
500	8.5160	4.4229	1.4840	4.9229	8.4776	4.4871	1.5224	4.9871
	8.7266	4.1054	1.2734	4.6054	8.7046	4.1480	1.2954	4.6480
550	8.3046	4.7302	1.6954	5.2302	8.2571	4.8028	1.7429	5.3028
	8.3545	4.7083	1.6455	5.2083	8.3179	4.7692	1.6821	5.2692
600	8.0962	5.0093	1.9038	5.5093	8.0392	5.0897	1.9608	5.5897
	8.2768	4.7839	1.7232	5.2839	8.2380	4.8448	1.7620	5.3448

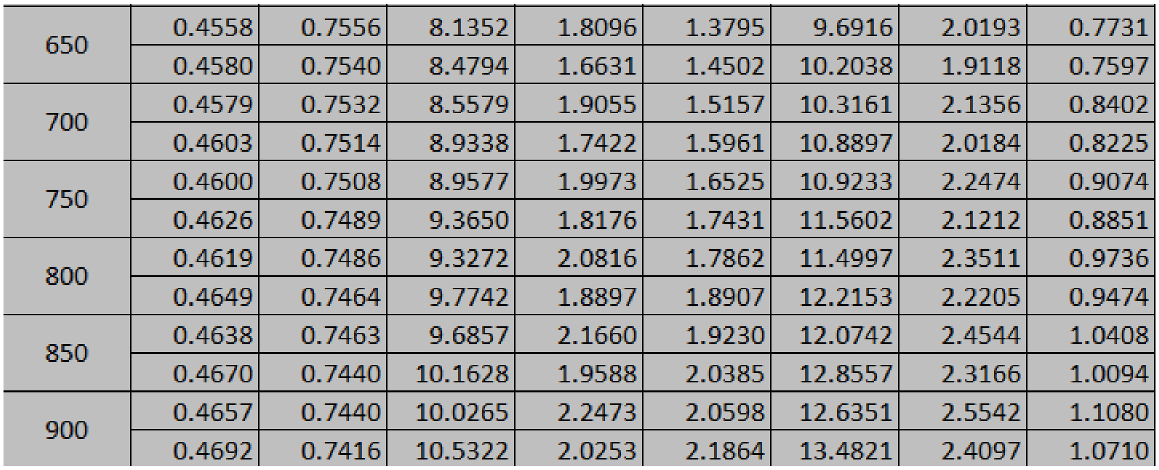


650	7.8922	5.2628	2.1078	5.7628	7.8270	5.3480	2.1730	5.8480
	7.9257	5.2508	2.0743	5.7508	7.8691	5.3291	2.1309	5.8291
700	7.6937	5.4933	2.3063	5.9933	7.6195	5.5843	2.3805	6.0843
	7.8407	5.3368	2.1593	5.8368	7.7820	5.4146	2.2180	5.9146
750	7.5013	5.7031	2.4987	6.2031	7.4180	5.7995	2.5820	6.2995
	7.5280	5.6913	2.4720	6.1913	7.4510	5.7835	2.5490	6.2835
800	7.3171	5.8922	2.6829	6.3922	7.2233	5.9956	2.7767	6.4956
	7.4303	5.7881	2.5697	6.2881	7.3514	5.8796	2.6486	6.3796
850	7.1384	6.0668	2.8616	6.5668	7.0356	6.1746	2.9644	6.6746
	7.1618	6.0550	2.8382	6.5550	7.0657	6.1576	2.9343	6.6576
900	6.9664	6.2268	3.0336	6.7268	6.8550	6.3383	3.1450	6.8383
	7.0488	6.1600	2.9512	6.6600	6.9505	6.2621	3.0495	6.7621

Table 1: Total Displacement of node 17 (5Q8)

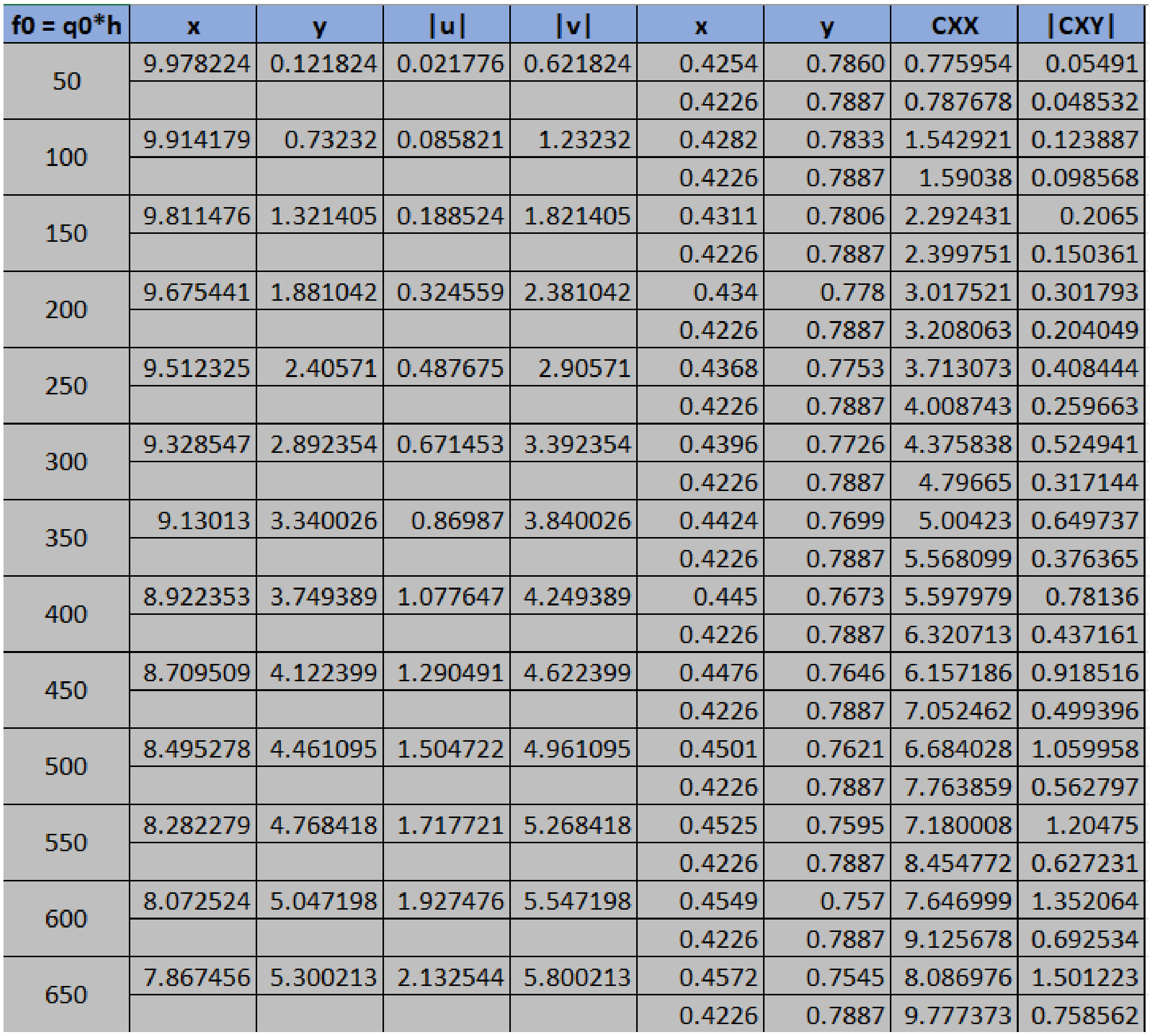


f0 = q0*h			Cauchy Stress			Piola-Kirchhoff Stress		
	x	y	CXX	CYY	|CXY|	SXX	SYY	|SXY|
50	0.4253	0.7861	0.7776	0.1819	0.0539	0.7885	0.1840	0.0487
	0.4254	0.7860	0.7929	0.1840	0.0545	0.8042	0.1862	0.0491
100	0.4280	0.7835	1.5457	0.3579	0.1198	1.5894	0.3661	0.0994
	0.4282	0.7833	1.5779	0.3584	0.1220	1.6236	0.3670	0.1004
150	0.4308	0.7810	2.2962	0.5268	0.1975	2.3950	0.5448	0.1521
	0.4310	0.7806	2.3476	0.5225	0.2022	2.4514	0.5416	0.1540
200	0.4335	0.7783	3.0226	0.6880	0.2861	3.1978	0.7191	0.2070
	0.4339	0.7779	3.0961	0.6761	0.2943	3.2812	0.7093	0.2097
250	0.4362	0.7757	3.7200	0.8411	0.3845	3.9918	0.8880	0.2640
	0.4367	0.7752	3.8185	0.8193	0.3970	4.1075	0.8699	0.2671
300	0.4389	0.7731	4.3854	0.9863	0.4915	4.7721	1.0509	0.3230
	0.4396	0.7724	4.5117	0.9527	0.5092	4.9255	1.0232	0.3261
350	0.4415	0.7706	5.0172	1.1237	0.6057	5.5354	1.2076	0.3838
	0.4424	0.7697	5.1731	1.0766	0.6293	5.7310	1.1693	0.3864
400	0.4441	0.7680	5.6151	1.2537	0.7258	6.2795	1.3579	0.4462
	0.4452	0.7670	5.8027	1.1921	0.7562	6.5221	1.3086	0.4476
450	0.4466	0.7655	6.1793	1.3767	0.8507	7.0025	1.5018	0.5098
	0.4478	0.7643	6.4004	1.2997	0.8886	7.2971	1.4414	0.5096
500	0.4491	0.7630	6.7118	1.4933	0.9793	7.7050	1.6396	0.5746
	0.4505	0.7617	6.9668	1.4004	1.0254	8.0548	1.5682	0.5721
550	0.4514	0.7605	7.2141	1.6040	1.1108	8.3870	1.7716	0.6402
	0.4531	0.7590	7.5032	1.4948	1.1658	8.7948	1.6894	0.6349
600	0.4536	0.7580	7.6879	1.7093	1.2444	9.0489	1.8981	0.7064
	0.4556	0.7564	8.0111	1.5836	1.3088	9.5173	1.8055	0.6978



650	0.4558	0.7556	8.1352	1.8096	1.3795	9.6916	2.0193	0.7731
	0.4580	0.7540	8.4794	1.6631	1.4502	10.2038	1.9118	0.7597
700	0.4579	0.7532	8.5579	1.9055	1.5157	10.3161	2.1356	0.8402
	0.4603	0.7514	8.9338	1.7422	1.5961	10.8897	2.0184	0.8225
750	0.4600	0.7508	8.9577	1.9973	1.6525	10.9233	2.2474	0.9074
	0.4626	0.7489	9.3650	1.8176	1.7431	11.5602	2.1212	0.8851
800	0.4619	0.7486	9.3272	2.0816	1.7862	11.4997	2.3511	0.9736
	0.4649	0.7464	9.7742	1.8897	1.8907	12.2153	2.2205	0.9474
850	0.4638	0.7463	9.6857	2.1660	1.9230	12.0742	2.4544	1.0408
	0.4670	0.7440	10.1628	1.9588	2.0385	12.8557	2.3166	1.0094
900	0.4657	0.7440	10.0265	2.2473	2.0598	12.6351	2.5542	1.1080
	0.4692	0.7416	10.5322	2.0253	2.1864	13.4821	2.4097	1.0710

*Table 2: Stresses (*10^-5) evaluated at left-most gauss point nearest the top of element 1 (5Q8)*



f0 = q0*h	x	y	|u|	|v|	x	y	CXX	|CXY|
50	9.978224	0.121824	0.021776	0.621824	0.4254	0.7860	0.775954	0.05491
					0.4226	0.7887	0.787678	0.048532
100	9.914179	0.73232	0.085821	1.23232	0.4282	0.7833	1.542921	0.123887
					0.4226	0.7887	1.59038	0.098568
150	9.811476	1.321405	0.188524	1.821405	0.4311	0.7806	2.292431	0.2065
					0.4226	0.7887	2.399751	0.150361
200	9.675441	1.881042	0.324559	2.381042	0.434	0.778	3.017521	0.301793
					0.4226	0.7887	3.208063	0.204049
250	9.512325	2.40571	0.487675	2.90571	0.4368	0.7753	3.713073	0.408444
					0.4226	0.7887	4.008743	0.259663
300	9.328547	2.892354	0.671453	3.392354	0.4396	0.7726	4.375838	0.524941
					0.4226	0.7887	4.79665	0.317144
350	9.13013	3.340026	0.86987	3.840026	0.4424	0.7699	5.00423	0.649737
					0.4226	0.7887	5.568099	0.376365
400	8.922353	3.749389	1.077647	4.249389	0.445	0.7673	5.597979	0.78136
					0.4226	0.7887	6.320713	0.437161
450	8.709509	4.122399	1.290491	4.622399	0.4476	0.7646	6.157186	0.918516
					0.4226	0.7887	7.052462	0.499396
500	8.495278	4.461095	1.504722	4.961095	0.4501	0.7621	6.684028	1.059958
					0.4226	0.7887	7.763859	0.562797
550	8.282279	4.768418	1.717721	5.268418	0.4525	0.7595	7.180008	1.20475
					0.4226	0.7887	8.454772	0.627231
600	8.072524	5.047198	1.927476	5.547198	0.4549	0.757	7.646999	1.352064
					0.4226	0.7887	9.125678	0.692534
650	7.867456	5.300213	2.132544	5.800213	0.4572	0.7545	8.086976	1.501223
					0.4226	0.7887	9.777373	0.758562

700	7.668068	5.530089	2.331932	6.030089	0.4594	0.752	8.50188	1.651674
					0.4226	0.7887	10.4108	0.825187
750	7.475004	5.739248	2.524996	6.239248	0.4615	0.7496	8.89357	1.802969
					0.4226	0.7887	11.02697	0.892295
800	7.288644	5.929892	2.711356	6.429892	0.4635	0.7472	9.263788	1.954747
					0.4226	0.7887	11.62692	0.959791
850	7.111413	6.101288	2.888587	6.601288	0.4655	0.7449	9.605038	2.102051
					0.4226	0.7887	12.19591	1.026032
900	6.939197	6.260413	3.060803	6.760413	0.4674	0.7426	9.936603	2.253453
					0.4226	0.7887	12.76516	1.093911
950	6.773775	6.406435	3.226225	6.906435	0.4693	0.7403	10.2515	2.404826
					0.4226	0.7887	13.32174	1.162021
1000	6.615008	6.540705	3.384992	7.040705	0.4711	0.738	10.55069	2.555848
					0.4226	0.7887	13.86603	1.230252
1050	6.462707	6.664441	3.537293	7.164441	0.4728	0.7357	10.83527	2.706392
					0.4226	0.7887	14.39883	1.298558
1100	6.316653	6.778721	3.683347	7.278721	0.4745	0.7334	11.10626	2.85636
					0.4226	0.7887	14.92089	1.366898

*Table 3: Total displacement of node 22 and stresses (*10^-5) (5Q9)*

Plots

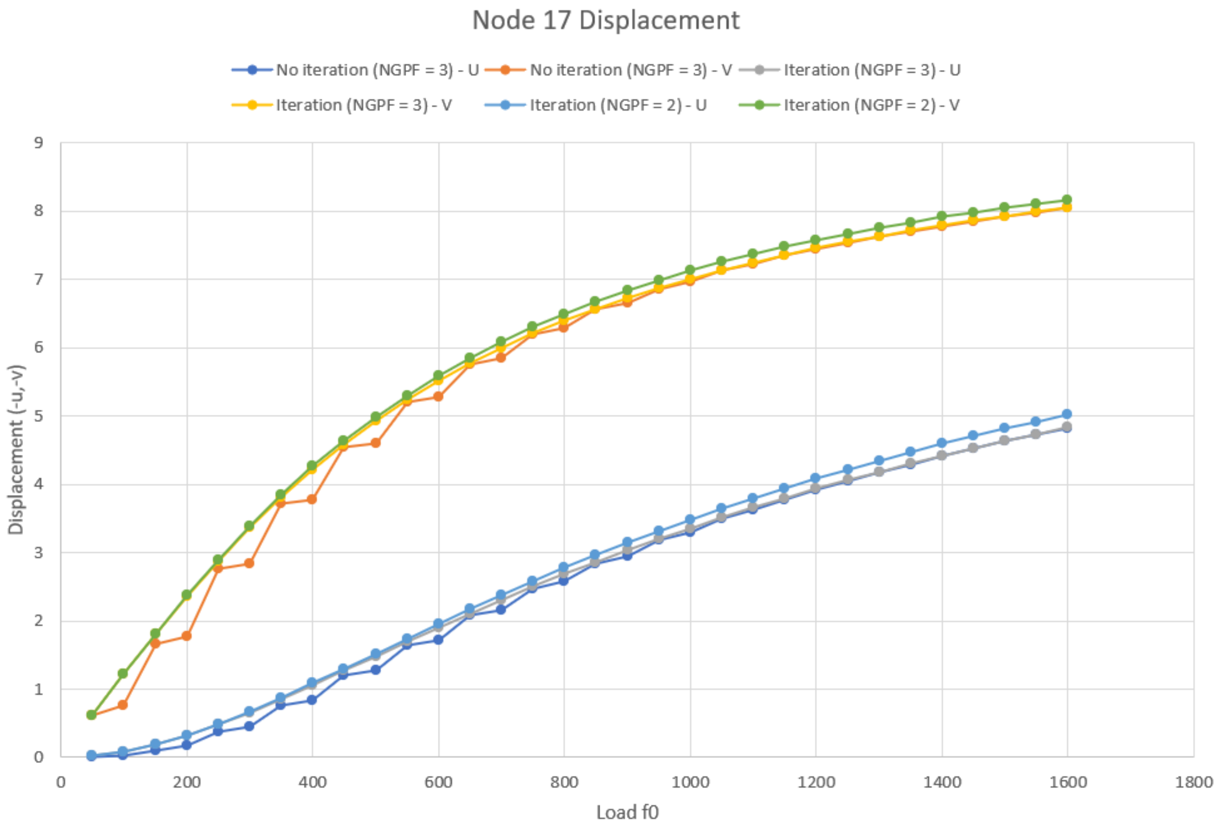


*Figure 1: Node 17 displacements (-u,-v) vs load f0 = q0*h*

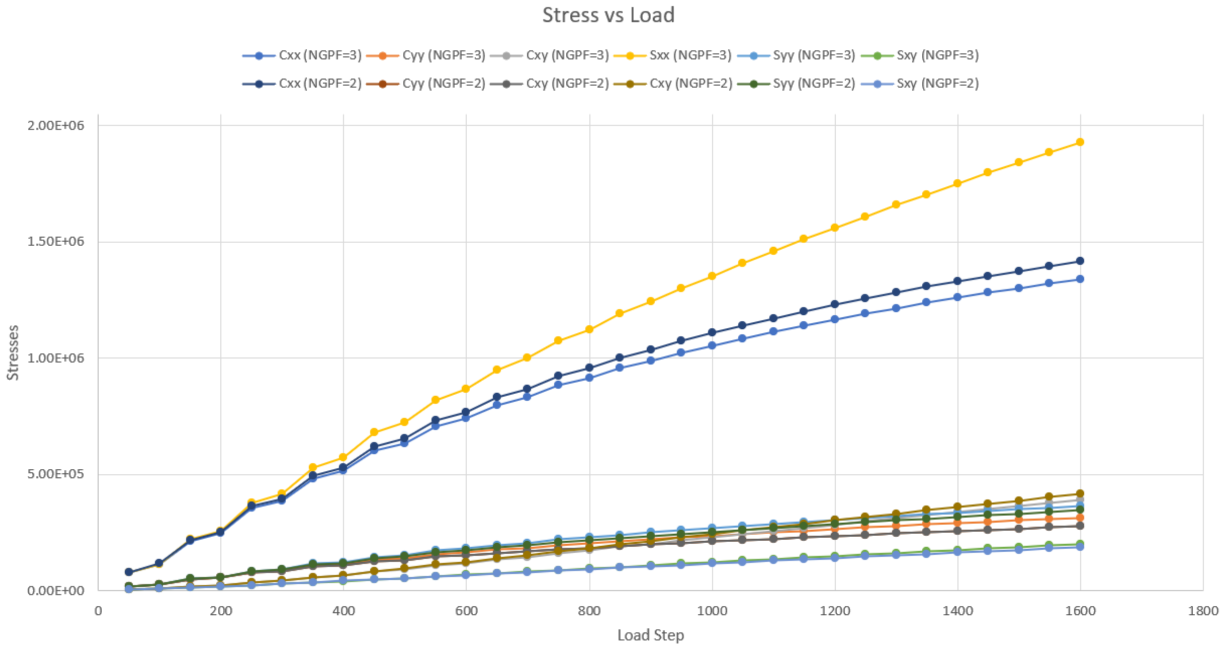


*Figure 2: Stresses vs load f0 = q0*h*

```
%% Pseudo Code
% Name: Manav Kothari
%UIN: 133008008

%% Assignment 7

Inputs

Call MeshR function to generate mesh
Call PlotMesh function to plot the mesh

Define DOF_NOD

Calculate the components of C

Initialize GCU, GPU, and GLS

for NL = 1:NLS % Load Step for loop
    Calculate the load for that particular step
    while iter<=ITERMAX && convergence == 0
        Initialize GLK and GLF

        for N = 1:NEM
            Calculate ELS and ELXY for every element

            Call ELEMATRICS2D function to calculate ELK and ELF

            Assemble the ELK and ELF matrix into GLK and GLF

        end

        Call CONTBCS function to impose boundary conditions

        Calculate iterative solution DELU
        % Note, the formulation of this method inherents NI↙
```

```
algorithm.
        % That means, this method already imposes NI

        for I = 1:NNM
            Update the solution vector and nodal coordinates
        end

        if MODEL ~= 1
            Perform iterative method to solve for the solution
        else
            Do not perform iteration and calculate solution↙
based on 1st iteration itself
        end
    end % End of iterative loop

    %% Post processing of results

    if IGRAD ~= 0 %IGRAD = 0 means don't calculate stresses
        for I = 1:NPE
            Calculate ELXY and ELS from updated GLXY and GLS↙
for the required element
            Call Stress2D function to get all the required↙
stresses and strains.
        end
    end
end % End of load step loop

%↙
---------------------------------------------------------------↙
------------------------------ %

function [ELK,ELF] = ELEMATRICS2D(NDF,NPE,ELXY,ELS,NGPF,C,↙
thick,F,LFORM)
```

```
Initialize ELK and ELF

for NI = 1:NGPF
    for NJ = 1:NGPF % Perform full integration
        Call INTERPLN2D function for SFL, GDSFL, and JAC

        Calculate Green Strain and 2nd Piola-Kirchhoff stress↙
for Total lagrange
        OR
        Calculate Euler Strain and Cauchy stress for Updated↙
Lagrange

        for I = 1:NPE
            Calculate components of ELF matrix
            for J = 1:NPE
                calculate components of ELK matrix
            end
        end
    end
end
end

%↙
----------------------------------------------------------------↙
------------------------- %

function SS = STRESS2D(NDF,ELXY,ELS,LGP,NPE,C)

for NI = 1:LGP
    for NJ = 1:LGP

        Calculate XC, YC, U1X, U1Y, V1X, V1Y for the particular↙
gauss point

        Calculate Euler strain and Cauchy Stress Tensor
        Update ELXY

        Calculate Green Strain and 2nd Piola Kirchhoff Stress↙
tensor
    end
end

Export the required stress tensor and strains
end
%↙
---------------------------------------------------------------↙
------------------------- %
```