

MECH530 – Assignment 5

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CHOSEN MATERIAL: graphite_epoxy_1

===== GEOMETRY PARAMETERS =====

Layer Number	Type	Thickness (mm)	Orientation (degrees)

1	ply	0.125	0
2	ply	0.125	0
3	ply	0.125	20
4	ply	0.125	-20
5	ply	0.125	0
6	ply	0.125	90
-	core	10.000	N/A
7	ply	0.125	90
8	ply	0.125	0
9	ply	0.125	-20
10	ply	0.125	20
11	ply	0.125	0
12	ply	0.125	0

===== MATRICES =====

[A] Matrix (in N/m):

2.117e+08	1.249e+07	1.055e-10
1.249e+07	6.027e+07	2.519e-09
1.055e-10	2.519e-09	1.890e+07

[a] Matrix (in m/N):

4.783e-09	-9.911e-10	1.054e-25
-9.911e-10	1.680e-08	-2.234e-24
1.054e-25	-2.234e-24	5.291e-08

[D] Matrix (in Nm):

6.268e+03	3.611e+02	1.578e+01
3.611e+02	1.602e+03	2.736e+00
1.578e+01	2.736e+00	5.465e+02

[d] Matrix (in (Nm)⁻¹):

1.617e-04	-3.642e-05	-4.484e-06
-3.642e-05	6.323e-04	-2.114e-06
-4.484e-06	-2.114e-06	1.830e-03

===== CURVATURES AND OFF-AXIS STRAIN =====

N_vector (N) = [5000.000; 0.000; 0.000]

M_vector (Nm) = [-1250.000; 0.000; 0.000]

epsilon_o_vector = [
2.391e-05
-4.955e-06
5.271e-22
]

k_vector (m⁻¹) = [
-2.021e-01
4.553e-02
5.605e-03
]

===== PER-LAYER STRESSES AND STRAINS =====

Ply	Angle (deg)	z_height (m)	Surface	Epsilon_x	epsilon_vector	on_axis_strain	on_axis_stress
1	0	0.00575	{'Top' }	-0.001138	{'[-1.138e-03, 2.568e-04, 3.223e-05]' }	{'[-1.138e-03, 2.568e-04, 3.223e-05]' }	{'[-2.061e+02, -6.394e-01, 2.311e-01]' }
1	0	0.005625	{'Bottom' }	-0.0011127	{'[-1.113e-03, 2.511e-04, 3.153e-05]' }	{'[-1.113e-03, 2.511e-04, 3.153e-05]' }	{'[-2.016e+02, -6.252e-01, 2.261e-01]' }
2	0	0.005625	{'Top' }	-0.0011127	{'[-1.113e-03, 2.511e-04, 3.153e-05]' }	{'[-1.113e-03, 2.511e-04, 3.153e-05]' }	{'[-2.016e+02, -6.252e-01, 2.261e-01]' }
2	0	0.0055	{'Bottom' }	-0.0010874	{'[-1.087e-03, 2.454e-04, 3.083e-05]' }	{'[-1.087e-03, 2.454e-04, 3.083e-05]' }	{'[-1.970e+02, -6.109e-01, 2.210e-01]' }
3	20	0.0055	{'Top' }	-0.00092161	{'[-1.087e-03, 2.454e-04, 3.083e-05]' }	{'[-9.216e-04, 7.961e-05, 8.804e-04]' }	{'[-1.673e+02, -1.846e+00, 6.312e+00]' }
3	20	0.005375	{'Bottom' }	-0.0009002	{'[-1.062e-03, 2.397e-04, 3.013e-05]' }	{'[-9.002e-04, 7.777e-05, 8.599e-04]' }	{'[-1.634e+02, -1.803e+00, 6.166e+00]' }
4	-20	0.005375	{'Top' }	-0.00091957	{'[-1.062e-03, 2.397e-04, 3.013e-05]' }	{'[-9.196e-04, 9.714e-05, -8.138e-04]' }	{'[-1.669e+02, -1.659e+00, -5.835e+00]' }
4	-20	0.00525	{'Bottom' }	-0.0008977	{'[-1.037e-03, 2.341e-04, 2.943e-05]' }	{'[-8.977e-04, 9.484e-05, -7.944e-04]' }	{'[-1.629e+02, -1.619e+00, -5.696e+00]' }
5	0	0.00525	{'Top' }	-0.0010369	{'[-1.037e-03, 2.341e-04, 2.943e-05]' }	{'[-1.037e-03, 2.341e-04, 2.943e-05]' }	{'[-1.878e+02, -5.823e-01, 2.110e-01]' }
5	0	0.005125	{'Bottom' }	-0.0010117	{'[-1.012e-03, 2.284e-04, 2.873e-05]' }	{'[-1.012e-03, 2.284e-04, 2.873e-05]' }	{'[-1.833e+02, -5.680e-01, 2.060e-01]' }
6	90	0.005125	{'Top' }	0.00022837	{'[-1.012e-03, 2.284e-04, 2.873e-05]' }	{'[2.284e-04, -1.012e-03, -2.873e-05]' }	{'[3.859e+01, -9.805e+00, -2.060e-01]' }
6	90	0.005	{'Bottom' }	0.00022268	{'[-9.864e-04, 2.227e-04, 2.803e-05]' }	{'[2.227e-04, -9.864e-04, -2.803e-05]' }	{'[3.763e+01, -9.560e+00, -2.009e-01]' }
7	90	-0.005	{'Top' }	-0.00023259	{'[1.034e-03, -2.326e-04, -2.803e-05]' }	{'[-2.326e-04, 1.034e-03, 2.803e-05]' }	{'[-3.929e+01, 1.003e+01, 2.009e-01]' }
7	90	-0.005125	{'Bottom' }	-0.00023828	{'[1.059e-03, -2.383e-04, -2.873e-05]' }	{'[-2.383e-04, 1.059e-03, 2.873e-05]' }	{'[-4.025e+01, 1.027e+01, 2.060e-01]' }
8	0	-0.005125	{'Top' }	0.0010595	{'[1.059e-03, -2.383e-04, -2.873e-05]' }	{'[1.059e-03, -2.383e-04, -2.873e-05]' }	{'[1.919e+02, 6.040e-01, -2.060e-01]' }
8	0	-0.00525	{'Bottom' }	0.0010847	{'[1.085e-03, -2.440e-04, -2.943e-05]' }	{'[1.085e-03, -2.440e-04, -2.943e-05]' }	{'[1.965e+02, 6.183e-01, -2.110e-01]' }
9	-20	-0.00525	{'Top' }	0.00093878	{'[1.085e-03, -2.440e-04, -2.943e-05]' }	{'[9.388e-04, -9.800e-05, 8.315e-04]' }	{'[1.704e+02, 1.706e+00, 5.962e+00]' }
9	-20	-0.005375	{'Bottom' }	0.00096064	{'[1.110e-03, -2.497e-04, -3.013e-05]' }	{'[9.606e-04, -1.003e-04, 8.509e-04]' }	{'[1.744e+02, 1.745e+00, 6.101e+00]' }
10	20	-0.005375	{'Top' }	0.00094127	{'[1.110e-03, -2.497e-04, -3.013e-05]' }	{'[9.413e-04, -8.093e-05, -8.971e-04]' }	{'[1.709e+02, 1.890e+00, -6.432e+00]' }
10	20	-0.0055	{'Bottom' }	0.00096268	{'[1.135e-03, -2.554e-04, -3.083e-05]' }	{'[9.627e-04, -8.277e-05, -9.175e-04]' }	{'[1.748e+02, 1.932e+00, -6.578e+00]' }
11	0	-0.0055	{'Top' }	0.0011353	{'[1.135e-03, -2.554e-04, -3.083e-05]' }	{'[1.135e-03, -2.554e-04, -3.083e-05]' }	{'[2.057e+02, 6.469e-01, -2.210e-01]' }
11	0	-0.005625	{'Bottom' }	0.0011605	{'[1.161e-03, -2.610e-04, -3.153e-05]' }	{'[1.161e-03, -2.610e-04, -3.153e-05]' }	{'[2.102e+02, 6.612e-01, -2.261e-01]' }
12	0	-0.005625	{'Top' }	0.0011605	{'[1.161e-03, -2.610e-04, -3.153e-05]' }	{'[1.161e-03, -2.610e-04, -3.153e-05]' }	{'[2.102e+02, 6.612e-01, -2.261e-01]' }
12	0	-0.00575	{'Bottom' }	0.0011858	{'[1.186e-03, -2.667e-04, -3.223e-05]' }	{'[1.186e-03, -2.667e-04, -3.223e-05]' }	{'[2.148e+02, 6.755e-01, -2.311e-01]' }

===== MAX STRESS CRITERION CONCLUSIONS =====

First failure occurs in Ply 10 (20.000 degrees) on the Bottom surface.

Smallest R value (failure): R = 1.441

Failure Mode: Shear

M_i * R = [-1801.357; 0.000; 0.000] Nm

N_i * R = [7205.430; 0.000; 0.000] N

===== QUADRATIC CRITERION CONCLUSIONS =====

First failure occurs in Ply 10 (20.000 degrees) on the Bottom surface.

Smallest R value (failure): R = 1.383

M_i * R = [-1729.359; 0.000; 0.000] Nm

N_i * R = [6917.436; 0.000; 0.000] N

===== HASHIN CRITERION CONCLUSIONS =====

First failure occurs in Ply 10 (20.000 degrees) on the Bottom surface.

Smallest R value (failure): R = 1.421

Failure Mode: Fiber Tension

M_i * R = [-1776.500; 0.000; 0.000] Nm

N_i * R = [7106.000; 0.000; 0.000] N

All results are summarized (All R values) are summarized below. Note that invalid values of R (i.e., smaller than 1 for Max & Hash, or complex-valued) have been replaced with N/A.

Ply	Angle (deg)	Max					Quad		Hash			
		FT	FC	MT	MC	S	(+)	(-)	FT	FC	MT	MC
1	0	N/A	7.2763	N/A	384.71	41.024	7.6929	-6.9746	N/A	7.2763	N/A	N/A
1	0	N/A	7.4415	N/A	393.5	41.935	7.8673	-7.1329	N/A	7.4415	N/A	N/A
2	0	N/A	7.4415	N/A	393.5	41.935	7.8673	-7.1329	N/A	7.4415	N/A	N/A
2	0	N/A	7.6143	N/A	402.71	42.888	8.0498	-7.2985	N/A	7.6143	N/A	N/A
3	20	N/A	8.9644	N/A	133.25	1.5018	1.5272	-1.4421	N/A	8.9644	N/A	N/A
3	20	N/A	9.1776	N/A	136.42	1.5375	1.5635	-1.4763	N/A	9.1776	N/A	N/A
4	-20	N/A	8.9871	N/A	148.29	1.6247	1.6472	-1.5581	N/A	8.9871	N/A	N/A
4	-20	N/A	9.206	N/A	151.91	1.6643	1.6874	-1.5961	N/A	9.206	N/A	N/A
5	0	N/A	7.9853	N/A	422.48	44.931	8.4415	-7.6539	N/A	7.9853	N/A	N/A
5	0	N/A	8.1846	N/A	433.11	46.027	8.652	-7.8449	N/A	8.1846	N/A	N/A
6	90	38.8711	38.871	N/A	25.089	46.027	19.148	-3.8835	29.6973	N/A	N/A	N/A
6	90	39.8644	39.864	N/A	25.731	47.177	19.638	-3.983	30.4493	N/A	N/A	N/A
7	90	38.177	38.177	3.9894	24.535	47.177	3.8006	-18.794	38.1768	38.1768	3.9752	N/A
7	90	37.265	37.265	3.8943	23.95	46.027	3.71	-18.345	37.2649	37.2649	3.8805	N/A
8	0	7.8151	7.8151	66.2253	407.29	46.027	7.4975	-8.2827	7.7048	7.7048	37.795	N/A
8	0	7.6331	7.6331	64.6944	397.87	44.931	7.3228	-8.0896	7.5253	7.5253	36.9036	N/A
9	-20	8.803	8.803	23.4511	144.22	1.59	1.5246	-1.6124	1.5647	1.5647	1.5864	N/A
9	-20	8.6027	8.6027	22.9192	140.95	1.5539	1.4899	-1.5757	1.5291	1.5291	1.5503	N/A
10	20	8.7771	8.7771	21.1694	130.19	1.4739	1.415	-1.4998	1.4536	1.4536	1.4703	N/A
10	20	8.5819	8.5819	20.6991	127.3	1.4411	1.3835	-1.4655	1.4212	1.4212	1.4376	N/A
11	0	7.2935	7.2935	61.8356	380.29	42.888	6.9969	-7.7292	7.1902	7.1902	35.2414	N/A
11	0	7.1347	7.1347	60.4989	372.07	41.935	6.8445	-7.5608	7.0336	7.0336	34.2521	N/A
12	0	7.1347	6.9827	59.2188	364.2	41.024	6.8445	-7.5608	7.0336	6.8837	34.4652	N/A
12	0	7.1347	6.9827	59.2188	364.2	41.024	6.6987	-7.3996	6.8837	6.8837	33.7224	N/A