DESIGN #1

Note: The angle was chosen using something learned in my first year (Prof Higgins), where we learned that this type of stress is resisted in braided hoses, and the optimal angle is around 55 degrees. Upon trying this angle and then cycling through other angles, I found that indeed this was the strongest ply orientation.

```
CHOSEN MATERIAL: graphite_epoxy_1
```

```
================= GEOMETRY PARAMETERS =================

Layer Number    Type        Thickness (mm)  Orientation (degrees)
----------------------------------------------------------------
1               ply         0.125                              55
2               ply         0.125                             -55
3               ply         0.125                              55
4               ply         0.125                             -55
5               ply         0.125                              55
6               ply         0.125                             -55
7               ply         0.125                              55
8               ply         0.125                             -55
9               ply         0.125                              55
10              ply         0.125                             -55
11              ply         0.125                              55
12              ply         0.125                             -55
-               core        10.000                            N/A
13              ply         0.125                             -55
14              ply         0.125                              55
15              ply         0.125                             -55
16              ply         0.125                              55
17              ply         0.125                             -55
18              ply         0.125                              55
19              ply         0.125                             -55
```

20	ply	0.125	55
21	ply	0.125	-55
22	ply	0.125	55
23	ply	0.125	-55
24	ply	0.125	55

```
================== MATRICES ==================

[A] Matrix (in N/m):
     9.584e+07        1.131e+08        0.000e+00
     1.131e+08        2.718e+08        0.000e+00
     0.000e+00        0.000e+00        1.259e+08


[a] Matrix (in m/N):
     2.051e-08       -8.537e-09        0.000e+00
    -8.537e-09        7.233e-09        0.000e+00
     0.000e+00        0.000e+00        7.940e-09


[D] Matrix (in Nm):
     3.187e+03        3.761e+03        5.954e+01
     3.761e+03        9.036e+03        1.142e+02
     5.954e+01        1.142e+02        4.187e+03


[d] Matrix (in (Nm)^-1):
     6.168e-04       -2.567e-04       -1.770e-06
    -2.567e-04        2.175e-04       -2.282e-06
    -1.770e-06       -2.282e-06        2.389e-04
```

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

N_vector (N) = [150000.000; 300000.000; 0.000]

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

epsilon_o_vector = [
  5.155e-04
  8.893e-04
  0.000e+00
]

k_vector (m^-1) = [
  0.000e+00
  0.000e+00
  0.000e+00
]

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

Ply	Angle (deg)	z_height (m)	Surface	Epsilon_x	epsilon_vector	on_axis_strain	on_axis_stress
1	55	0.0065	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
1	55	0.006375	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
2	-55	0.006375	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
2	-55	0.00625	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
3	55	0.00625	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
3	55	0.006125	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
4	-55	0.006125	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
4	-55	0.006	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
5	55	0.006	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
5	55	0.005875	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
6	-55	0.005875	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
6	-55	0.00575	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
7	55	0.00575	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
7	55	0.005625	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
8	-55	0.005625	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
8	-55	0.0055	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
9	55	0.0055	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
9	55	0.005375	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
10	-55	0.005375	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
10	-55	0.00525	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
11	55	0.00525	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
11	55	0.005125	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
12	-55	0.005125	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
12	-55	0.005	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
13	-55	-0.005	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
13	-55	-0.005125	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
14	55	-0.005125	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
14	55	-0.00525	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
15	-55	-0.00525	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
15	-55	-0.005375	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
16	55	-0.005375	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
16	55	-0.0055	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
17	-55	-0.0055	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
17	-55	-0.005625	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
18	55	-0.005625	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
18	55	-0.00575	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
19	-55	-0.00575	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
19	-55	-0.005875	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
20	55	-0.005875	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
20	55	-0.006	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
21	-55	-0.006	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
21	-55	-0.006125	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
22	55	-0.006125	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
22	55	-0.00625	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
23	-55	-0.00625	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
23	-55	-0.006375	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, -3.513e-04]'}	{'[1.412e+02, 8.825e+00, -2.519e+00]'}
24	55	-0.006375	{'Top' }	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }
24	55	-0.0065	{'Bottom'}	0.00076632	{'[5.155e-04, 8.893e-04, 0.000e+00]'}	{'[7.663e-04, 6.385e-04, 3.513e-04]' }	{'[1.412e+02, 8.825e+00, 2.519e+00]' }

```
================= QUADRATIC FAILURE CRITERIA COEFFICIENTS =================
F_xx: 4.444e-07
F_x: 0.000e+00
F_yy: 1.016e-04
F_y: 2.093e-02
F_s: 1.113e-02
F_xy: -3.360e-06


================= FAILURE CRITERIA =================

   Ply    Angle (deg)     Surface        R_1       R_2       R_3       R_4       R_5

   ___    _____    _____     _____     _____     _____     _____     _____


    1         55         {'Top'   }     10.625    10.625    4.5323    27.874    3.7636
    1         55         {'Bottom'}     10.625    10.625    4.5323    27.874    3.7636
    2        -55         {'Top'   }     10.625    10.625    4.5323    27.874    3.7636
    2        -55         {'Bottom'}     10.625    10.625    4.5323    27.874    3.7636
    3         55         {'Top'   }     10.625    10.625    4.5323    27.874    3.7636
    3         55         {'Bottom'}     10.625    10.625    4.5323    27.874    3.7636
    4        -55         {'Top'   }     10.625    10.625    4.5323    27.874    3.7636
    4        -55         {'Bottom'}     10.625    10.625    4.5323    27.874    3.7636
    5         55         {'Top'   }     10.625    10.625    4.5323    27.874    3.7636
    5         55         {'Bottom'}     10.625    10.625    4.5323    27.874    3.7636
    6        -55         {'Top'   }     10.625    10.625    4.5323    27.874    3.7636
    6        -55         {'Bottom'}     10.625    10.625    4.5323    27.874    3.7636
    7         55         {'Top'   }     10.625    10.625    4.5323    27.874    3.7636
    7         55         {'Bottom'}     10.625    10.625    4.5323    27.874    3.7636
    8        -55         {'Top'   }     10.625    10.625    4.5323    27.874    3.7636
    8        -55         {'Bottom'}     10.625    10.625    4.5323    27.874    3.7636
    9         55         {'Top'   }     10.625    10.625    4.5323    27.874    3.7636
    9         55         {'Bottom'}     10.625    10.625    4.5323    27.874    3.7636
   10        -55         {'Top'   }     10.625    10.625    4.5323    27.874    3.7636
   10        -55         {'Bottom'}     10.625    10.625    4.5323    27.874    3.7636
   11         55         {'Top'   }     10.625    10.625    4.5323    27.874    3.7636
   11         55         {'Bottom'}     10.625    10.625    4.5323    27.874    3.7636
   12        -55         {'Top'   }     10.625    10.625    4.5323    27.874    3.7636
   12        -55         {'Bottom'}     10.625    10.625    4.5323    27.874    3.7636
   13        -55         {'Top'   }     10.625    10.625    4.5323    27.874    3.7636
```

Ply	Angle	Surface					
13	-55	{'Bottom'}	10.625	10.625	4.5323	27.874	3.7636
14	55	{'Top' }	10.625	10.625	4.5323	27.874	3.7636
14	55	{'Bottom'}	10.625	10.625	4.5323	27.874	3.7636
15	-55	{'Top' }	10.625	10.625	4.5323	27.874	3.7636
15	-55	{'Bottom'}	10.625	10.625	4.5323	27.874	3.7636
16	55	{'Top' }	10.625	10.625	4.5323	27.874	3.7636
16	55	{'Bottom'}	10.625	10.625	4.5323	27.874	3.7636
17	-55	{'Top' }	10.625	10.625	4.5323	27.874	3.7636
17	-55	{'Bottom'}	10.625	10.625	4.5323	27.874	3.7636
18	55	{'Top' }	10.625	10.625	4.5323	27.874	3.7636
18	55	{'Bottom'}	10.625	10.625	4.5323	27.874	3.7636
19	-55	{'Top' }	10.625	10.625	4.5323	27.874	3.7636
19	-55	{'Bottom'}	10.625	10.625	4.5323	27.874	3.7636
20	55	{'Top' }	10.625	10.625	4.5323	27.874	3.7636
20	55	{'Bottom'}	10.625	10.625	4.5323	27.874	3.7636
21	-55	{'Top' }	10.625	10.625	4.5323	27.874	3.7636
21	-55	{'Bottom'}	10.625	10.625	4.5323	27.874	3.7636
22	55	{'Top' }	10.625	10.625	4.5323	27.874	3.7636
22	55	{'Bottom'}	10.625	10.625	4.5323	27.874	3.7636
23	-55	{'Top' }	10.625	10.625	4.5323	27.874	3.7636
23	-55	{'Bottom'}	10.625	10.625	4.5323	27.874	3.7636
24	55	{'Top' }	10.625	10.625	4.5323	27.874	3.7636
24	55	{'Bottom'}	10.625	10.625	4.5323	27.874	3.7636

Ply	Angle (deg)	Surface	R_quadratic_1	R_quadratic_2
1	55	{'Top' }	2.5757	-4.9145
1	55	{'Bottom'}	2.5757	-4.9145
2	-55	{'Top' }	2.5757	-4.9145
2	-55	{'Bottom'}	2.5757	-4.9145
3	55	{'Top' }	2.5757	-4.9145
3	55	{'Bottom'}	2.5757	-4.9145
4	-55	{'Top' }	2.5757	-4.9145
4	-55	{'Bottom'}	2.5757	-4.9145
5	55	{'Top' }	2.5757	-4.9145
5	55	{'Bottom'}	2.5757	-4.9145
6	-55	{'Top' }	2.5757	-4.9145

6	-55	{'Bottom'}	2.5757	-4.9145
7	55	{'Top' }	2.5757	-4.9145
7	55	{'Bottom'}	2.5757	-4.9145
8	-55	{'Top' }	2.5757	-4.9145
8	-55	{'Bottom'}	2.5757	-4.9145
9	55	{'Top' }	2.5757	-4.9145
9	55	{'Bottom'}	2.5757	-4.9145
10	-55	{'Top' }	2.5757	-4.9145
10	-55	{'Bottom'}	2.5757	-4.9145
11	55	{'Top' }	2.5757	-4.9145
11	55	{'Bottom'}	2.5757	-4.9145
12	-55	{'Top' }	2.5757	-4.9145
12	-55	{'Bottom'}	2.5757	-4.9145
13	-55	{'Top' }	2.5757	-4.9145
13	-55	{'Bottom'}	2.5757	-4.9145
14	55	{'Top' }	2.5757	-4.9145
14	55	{'Bottom'}	2.5757	-4.9145
15	-55	{'Top' }	2.5757	-4.9145
15	-55	{'Bottom'}	2.5757	-4.9145
16	55	{'Top' }	2.5757	-4.9145
16	55	{'Bottom'}	2.5757	-4.9145
17	-55	{'Top' }	2.5757	-4.9145
17	-55	{'Bottom'}	2.5757	-4.9145
18	55	{'Top' }	2.5757	-4.9145
18	55	{'Bottom'}	2.5757	-4.9145
19	-55	{'Top' }	2.5757	-4.9145
19	-55	{'Bottom'}	2.5757	-4.9145
20	55	{'Top' }	2.5757	-4.9145
20	55	{'Bottom'}	2.5757	-4.9145
21	-55	{'Top' }	2.5757	-4.9145
21	-55	{'Bottom'}	2.5757	-4.9145
22	55	{'Top' }	2.5757	-4.9145
22	55	{'Bottom'}	2.5757	-4.9145
23	-55	{'Top' }	2.5757	-4.9145
23	-55	{'Bottom'}	2.5757	-4.9145
24	55	{'Top' }	2.5757	-4.9145
24	55	{'Bottom'}	2.5757	-4.9145

Ply	Angle (deg)	Surface	R_hashin_1	R_hashin_2	R_hashin_3	R_hashin_4
1	55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
1	55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
2	-55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
2	-55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
3	55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
3	55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
4	-55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
4	-55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
5	55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
5	55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
6	-55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
6	-55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
7	55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
7	55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
8	-55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
8	-55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
9	55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
9	55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
10	-55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
10	-55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
11	55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
11	55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
12	-55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
12	-55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
13	-55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
13	-55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
14	55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
14	55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
15	-55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
15	-55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
16	55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
16	55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
17	-55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
17	-55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
18	55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"

18	55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
19	-55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
19	-55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
20	55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
20	55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
21	-55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
21	-55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
22	55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
22	55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
23	-55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
23	-55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"
24	55	{'Top' }	3.5476	"N/A"	2.8955	"N/A"
24	55	{'Bottom'}	3.5476	"N/A"	2.8955	"N/A"

================= MAX STRESS CRITERION CONCLUSIONS =================
First failure occurs in Ply 1 at 55.000 degrees on the Top surface.
Smallest R value (failure): R = 3.764
Failure Mode: Shear
M_i * R = [0.000; 0.000; 0.000] Nm
N_i * R = [564534.873; 1129069.746; 0.000] N

================= QUADRATIC CRITERION CONCLUSIONS =================
First failure occurs in Ply 1 at 55.000 degrees on the Top surface.
Smallest R value (failure): R = 2.576
M_i * R = [0.000; 0.000; 0.000] Nm
N_i * R = [386357.817; 772715.633; 0.000] N

================= HASHIN CRITERION CONCLUSIONS =================
First failure occurs in Ply 1 at 55.000 degrees on the Top surface.
Smallest R value (failure): R = 2.895
Failure Mode: Matrix Tension
M_i * R = [0.000; 0.000; 0.000] Nm
N_i * R = [434317.525; 868635.049; 0.000] N

DESIGN #2

Note: A "brute-force" method was used to get all permutations of laminates up to 100 plies thick. Below is the program output for the top 10 best laminates and their attributed K ratio.

My "official" result to submit is the following, with K = 4.0000318.

Schedule	Plies	D11	D22	K (D11/D22)

[5 -20 20 -30 30 5 -20 20 -30 30 5 -20 20 -30 30 5 -20 20 -30 30 5 -20 20 -30 30 5 -20 20 -30 30 5 -20 20 -30 30 5 -20 20 -30 30 5 -20 20 -30 30 20 -20 5 30 -30 20 -20 5 30 -30 20 -20 5 30 -30 20 -20 5 30 -30 20 -20 5 30 -30 20 -20 5 30 -30 20 -20 5 30 -30 20 -20 5 30 -30 20 -20 5] 88   3.023e+05   7.558e+04   4.0000318

Below is the top 10 results from this sweep:

Top 10 Results Closest to K = 4:

Schedule	Plies	D11	D22	K (D11/D22)

[5 -20 20 -30 30 5 -20 20 -30 30 5 -20 20 -30 30 5 -20 20 -30 30 5 -20 20 -30 30 5 -20 20 -30 30 5 -20 20 -30 30 5 -20 20 -30 30 5 -20 20 -30 30 20 -20 5 30 -30 20 -20 5 30 -30 20 -20 5 30 -30 20 -20 5 30 -30 20 -20 5 30 -30 20 -20 5 30 -30 20 -20 5 30 -30 20 -20 5 30 -30 20 -20 5] 88   3.023e+05   7.558e+04   4.0000318

[5 -20 20 30 -30 5 -20 20 30 -30 5 -20 20 30 -30 5 -20 20 30 -30 5 -20 20 30 -30 5 -20 20 30 -30 5 -20 20 30 -30 5 -20 20 30 -30 5 -20 20 30 -30 5 -20 20 30 30 20 -20 5 -30 30 20 -20 5 -30 30 20 -20 5 -30 30 20 -20 5 -30 30 20 -20 5 -30 30 20 -20 5 -30 30 20 -20 5 -30 30 20 -20 5 -30 30 20 -20 5]   88   3.023e+05   7.558e+04   4.0000318

[5 20 -20 -30 30 5 20 -20 -30 30 5 20 -20 -30 30 5 20 -20 -30 30 5 20 -20 -30 30 5 20 -20 -30 30 5 20 -20 -30 30 5 20 -20 -30 30 5 20 -20 -30 30 5 20 -20 -30 -30 -20 20 5 30 -30 -20 20 5 30 -30 -20 20 5 30 -30 -20 20 5 30 -30 -20 20 5 30 -30 -20 20 5 30 -30 -20 20 5 30 -30 -20 20 5 30 -30 -20 20 5] 88   3.023e+05   7.558e+04   4.0000318

[5 20 -20 30 -30 5 20 -20 30 -30 5 20 -20 30 -30 5 20 -20 30 -30 5 20 -20 30 -30 5 20 -20 30 -30 5 20 -20 30 -30 5 20 -20 30 -30 5 20 -20 30 -30 5 20 -20 30 -30 5 20 -20 30 30 -20 20 5 -30 30 -20 20 5 -30 30 -20 20 5 -30 30 -20 20 5 -30 30 -20 20 5 -30 30 -20 20 5 -30 30 -20 20 5 -30 30 -20 20 5]   88   3.023e+05   7.558e+04   4.0000318

[-5 -20 20 -30 30 -5 -20 20 -30 30 -5 -20 20 -30 30 -5 -20 20 -30 30 -5 -20 20 -30 30 -5 -20 20 -30 30 -5 -20 20 -30 30 -5 -20 20 -30 30 -5 -20 20 -30 30 -5 -20 20 -30 30 -5 -20 20 -30 -30 20 -20 -5 30 -30 20 -20 -5 30 -30 20 -20 -5 30 -30 20 -20 -5 30 -30 20 -20 -5 30 -30 20 -20 -5 30 -30 20 -20 -5]   88   3.023e+05   7.558e+04   4.0000318

[-5 -20 20 30 -30 -5 -20 20 30 -30 -5 -20 20 30 -30 -5 -20 20 30 -30 -5 -20 20 30 -30 -5 -20 20 30 -30 -5 -20 20 30 -30 -5 -20 20 30 -30 -5 -20 20 30 -30 -5 -20 20 30 30 20 -20 -5 -30 30 20 -20 -5 -30 30 20 -20 -5 -30 30 20 -20 -5 -30 30 20 -20 -5 -30 30 20 -20 -5 -30 30 20 -20 -5 -30 30 20 -20 -5 -30 30 20 -20 -5]   88   3.023e+05   7.558e+04   4.0000318

[-5 20 -20 -30 30 -5 20 -20 -30 30 -5 20 -20 -30 30 -5 20 -20 -30 30 -5 20 -20 -30 30 -5 20 -20 -30 30 -5 20 -20 -30 30 -5 20 -20 -30 -30 -20 20 -5 30 -30 -20 20 -5 30 -30 -20 20 -5 30 -30 -20 20 -5 30 -30 -20 20 -5 30 -30 -20 20 -5 30 -30 -20 20 -5 30 -30 -20 20 -5]   88   3.023e+05   7.558e+04   4.0000318

[-5 20 -20 30 -30 -5 20 -20 30 -30 -5 20 -20 30 -30 -5 20 -20 30 -30 -5 20 -20 30 -30 -5 20 -20 30 -30 -5 20 -20 30 -30 -5 20 -20 30 -30 -5 20 -20 30 -30 -5 20 -20 30 30 -20 20 -5 -30 30 -20 20 -5 -30 30 -20 20 -5 -30 30 -20 20 -5 -30 30 -20 20 -5 -30 30 -20 20 -5 -30 30 -20 20 -5 -30 30 -20 20 -5]   88   3.023e+05   7.558e+04   4.0000318

[-5 20 50 0 5 -5 20 50 0 5 -5 -5 5 0 50 20 -5 5 0 50 20 -5]   22   4.854e+03   1.214e+03   3.9999647
[5 20 50 0 -5 5 20 50 0 -5 5 5 -5 0 50 20 5 -5 0 50 20 5]   22   4.854e+03   1.214e+03   3.9999647

Design #3

Presented :
- Safety factor results
- Short summary of
- (1) number of layers
- (2) material chosen
- (3) ply orientation
- (4) mass of your design
- (5) Minimum safety factor results for load cases I and II.

Program output for Load 1 :

Ply	Angle (deg)	z_height (m)	Surface	Epsilon_x	epsilon_vector	on_axis_strain	on_axis_stress
1	0	0.002125	{'Top' }	-0.0041577	{'[-4.158e-03, 2.044e-03, -8.760e-04]'}	{'[-4.158e-03, 2.044e-03, -8.760e-04]' }	{'[-7.500e+02, 9.104e+00, -6.281e+00]' }
1	0	0.002	{'Bottom'}	-0.0039208	{'[-3.921e-03, 1.928e-03, -8.258e-04]'}	{'[-3.921e-03, 1.928e-03, -8.258e-04]' }	{'[-7.073e+02, 8.593e+00, -5.921e+00]' }
2	30	0.002	{'Top' }	-0.0028161	{'[-3.921e-03, 1.928e-03, -8.258e-04]'}	{'[-2.816e-03, 8.236e-04, 4.653e-03]' }	{'[-5.096e+02, 3.634e-01, 3.336e+01]' }
2	30	0.001875	{'Bottom'}	-0.0026456	{'[-3.684e-03, 1.813e-03, -7.756e-04]'}	{'[-2.646e-03, 7.743e-04, 4.372e-03]' }	{'[-4.788e+02, 3.465e-01, 3.135e+01]' }
3	-30	0.001875	{'Top' }	-0.001974	{'[-3.684e-03, 1.813e-03, -7.756e-04]'}	{'[-1.974e-03, 1.026e-04, -5.148e-03]' }	{'[-3.586e+02, -4.657e+00, -3.691e+01]'}
3	-30	0.00175	{'Bottom'}	-0.001847	{'[-3.447e-03, 1.697e-03, -7.254e-04]'}	{'[-1.847e-03, 9.671e-05, -4.817e-03]' }	{'[-3.355e+02, -4.350e+00, -3.454e+01]'}
4	45	0.00175	{'Top' }	-0.0012378	{'[-3.447e-03, 1.697e-03, -7.254e-04]'}	{'[-1.238e-03, -5.124e-04, 5.144e-03]' }	{'[-2.265e+02, -8.888e+00, 3.688e+01]' }
4	45	0.001625	{'Bottom'}	-0.0011522	{'[-3.210e-03, 1.581e-03, -6.752e-04]'}	{'[-1.152e-03, -4.770e-04, 4.791e-03]' }	{'[-2.109e+02, -8.273e+00, 3.435e+01]' }
5	-45	0.001625	{'Top' }	-0.00047701	{'[-3.210e-03, 1.581e-03, -6.752e-04]'}	{'[-4.770e-04, -1.152e-03, -4.791e-03]'}	{'[-9.006e+01, -1.330e+01, -3.435e+01]'}
5	-45	0.0015	{'Bottom'}	-0.00044156	{'[-2.973e-03, 1.465e-03, -6.250e-04]'}	{'[-4.416e-04, -1.067e-03, -4.438e-03]'}	{'[-8.337e+01, -1.231e+01, -3.182e+01]'}
6	30	0.0015	{'Top' }	-0.0021343	{'[-2.973e-03, 1.465e-03, -6.250e-04]'}	{'[-2.134e-03, 6.262e-04, 3.531e-03]' }	{'[-3.862e+02, 2.958e-01, 2.532e+01]' }
6	30	0.001375	{'Bottom'}	-0.0019638	{'[-2.736e-03, 1.349e-03, -5.748e-04]'}	{'[-1.964e-03, 5.768e-04, 3.251e-03]' }	{'[-3.554e+02, 2.789e-01, 2.331e+01]' }
7	-30	0.001375	{'Top' }	-0.0014661	{'[-2.736e-03, 1.349e-03, -5.748e-04]'}	{'[-1.466e-03, 7.906e-05, -3.826e-03]' }	{'[-2.663e+02, -3.429e+00, -2.743e+01]'}
7	-30	0.00125	{'Bottom'}	-0.0013391	{'[-2.500e-03, 1.234e-03, -5.246e-04]'}	{'[-1.339e-03, 7.318e-05, -3.495e-03]' }	{'[-2.433e+02, -3.122e+00, -2.506e+01]'}
8	45	0.00125	{'Top' }	-0.00089525	{'[-2.500e-03, 1.234e-03, -5.246e-04]'}	{'[-8.952e-04, -3.707e-04, 3.733e-03]' }	{'[-1.638e+02, -6.429e+00, 2.677e+01]' }
8	45	0.001125	{'Bottom'}	-0.0008096	{'[-2.263e-03, 1.118e-03, -4.744e-04]'}	{'[-8.096e-04, -3.352e-04, 3.380e-03]' }	{'[-1.482e+02, -5.814e+00, 2.424e+01]' }
9	-45	0.001125	{'Top' }	-0.00033523	{'[-2.263e-03, 1.118e-03, -4.744e-04]'}	{'[-3.352e-04, -8.096e-04, -3.380e-03]'}	{'[-6.329e+01, -9.347e+00, -2.424e+01]'}
9	-45	0.001	{'Bottom'}	-0.00029979	{'[-2.026e-03, 1.002e-03, -4.242e-04]'}	{'[-2.998e-04, -7.240e-04, -3.028e-03]'}	{'[-5.660e+01, -8.359e+00, -2.171e+01]'}
10	90	0.001	{'Top' }	0.001002	{'[-2.026e-03, 1.002e-03, -4.242e-04]'}	{'[1.002e-03, -2.026e-03, 4.242e-04]' }	{'[1.763e+02, -1.806e+01, 3.041e+00]' }
10	90	0.000875	{'Bottom'}	0.00088625	{'[-1.789e-03, 8.862e-04, -3.740e-04]'}	{'[8.862e-04, -1.789e-03, 3.740e-04]' }	{'[1.559e+02, -1.594e+01, 2.681e+00]' }
11	90	0.000875	{'Top' }	0.00088625	{'[-1.789e-03, 8.862e-04, -3.740e-04]'}	{'[8.862e-04, -1.789e-03, 3.740e-04]' }	{'[1.559e+02, -1.594e+01, 2.681e+00]' }
11	90	0.00075	{'Bottom'}	0.00077046	{'[-1.552e-03, 7.705e-04, -3.238e-04]'}	{'[7.705e-04, -1.552e-03, 3.238e-04]' }	{'[1.356e+02, -1.383e+01, 2.321e+00]' }
12	90	-0.000619	{'Top' }	-0.000619	{'[1.291e-03, -6.190e-04, 2.787e-04]' }	{'[-6.190e-04, 1.291e-03, -2.787e-04]' }	{'[-1.088e+02, 1.156e+01, -1.998e+00]' }
12	90	-0.000875	{'Bottom'}	-0.00073479	{'[1.527e-03, -7.348e-04, 3.289e-04]' }	{'[-7.348e-04, 1.527e-03, -3.289e-04]' }	{'[-1.292e+02, 1.367e+01, -2.358e+00]' }
13	90	-0.000875	{'Top' }	-0.00073479	{'[1.527e-03, -7.348e-04, 3.289e-04]' }	{'[-7.348e-04, 1.527e-03, -3.289e-04]' }	{'[-1.292e+02, 1.367e+01, -2.358e+00]' }
13	90	-0.001	{'Bottom'}	-0.00085058	{'[1.764e-03, -8.506e-04, 3.791e-04]' }	{'[-8.506e-04, 1.764e-03, -3.791e-04]' }	{'[-1.495e+02, 1.579e+01, -2.718e+00]' }
14	-45	-0.001	{'Top' }	0.00026732	{'[1.764e-03, -8.506e-04, 3.791e-04]' }	{'[2.673e-04, 6.464e-04, 2.615e-03]' }	{'[5.047e+01, 7.462e+00, 1.875e+01]' }
14	-45	-0.001125	{'Bottom'}	0.00030276	{'[2.001e-03, -9.664e-04, 4.293e-04]' }	{'[3.028e-04, 7.320e-04, 2.968e-03]' }	{'[5.717e+01, 8.451e+00, 2.128e+01]' }
15	45	-0.001125	{'Top' }	0.00073204	{'[2.001e-03, -9.664e-04, 4.293e-04]' }	{'[7.320e-04, 3.028e-04, -2.968e-03]' }	{'[1.340e+02, 5.253e+00, -2.128e+01]' }
15	45	-0.00125	{'Bottom'}	0.00081768	{'[2.238e-03, -1.082e-03, 4.795e-04]' }	{'[8.177e-04, 3.382e-04, -3.320e-03]' }	{'[1.496e+02, 5.868e+00, -2.381e+01]' }
16	-30	-0.00125	{'Top' }	0.0012004	{'[2.238e-03, -1.082e-03, 4.795e-04]' }	{'[1.200e-03, -4.449e-05, 3.115e-03]' }	{'[2.181e+02, 3.017e+00, 2.234e+01]' }
16	-30	-0.001375	{'Bottom'}	0.0013273	{'[2.475e-03, -1.198e-03, 5.297e-04]' }	{'[1.327e-03, -5.037e-05, 3.446e-03]' }	{'[2.412e+02, 3.324e+00, 2.471e+01]' }
17	30	-0.001375	{'Top' }	0.0017861	{'[2.475e-03, -1.198e-03, 5.297e-04]' }	{'[1.786e-03, -5.091e-04, -2.916e-03]' }	{'[3.233e+02, -9.301e-02, -2.091e+01]' }
17	30	-0.0015	{'Bottom'}	0.0019565	{'[2.712e-03, -1.314e-03, 5.799e-04]' }	{'[1.957e-03, -5.584e-04, -3.196e-03]' }	{'[3.541e+02, -1.099e-01, -2.292e+01]' }
18	-45	-0.0015	{'Top' }	0.00040909	{'[2.712e-03, -1.314e-03, 5.799e-04]' }	{'[4.091e-04, 9.890e-04, 4.026e-03]' }	{'[7.724e+01, 1.142e+01, 2.886e+01]' }
18	-45	-0.001625	{'Bottom'}	0.00044453	{'[2.949e-03, -1.430e-03, 6.301e-04]' }	{'[4.445e-04, 1.075e-03, 4.378e-03]' }	{'[8.393e+01, 1.241e+01, 3.139e+01]' }
19	45	-0.001625	{'Top' }	0.0010746	{'[2.949e-03, -1.430e-03, 6.301e-04]' }	{'[1.075e-03, 4.445e-04, -4.378e-03]' }	{'[1.967e+02, 7.712e+00, -3.139e+01]' }
19	45	-0.00175	{'Bottom'}	0.0011603	{'[3.186e-03, -1.545e-03, 6.803e-04]' }	{'[1.160e-03, 4.800e-04, -4.731e-03]' }	{'[2.123e+02, 8.327e+00, -3.392e+01]' }
20	-30	-0.00175	{'Top' }	0.0017083	{'[3.186e-03, -1.545e-03, 6.803e-04]' }	{'[1.708e-03, -6.802e-05, 4.437e-03]' }	{'[3.104e+02, 4.245e+00, 3.181e+01]' }
20	-30	-0.001875	{'Bottom'}	0.0018352	{'[3.422e-03, -1.661e-03, 7.305e-04]' }	{'[1.835e-03, -7.390e-05, 4.768e-03]' }	{'[3.335e+02, 4.552e+00, 3.418e+01]' }
21	30	-0.001875	{'Top' }	0.0024679	{'[3.422e-03, -1.661e-03, 7.305e-04]' }	{'[2.468e-03, -7.065e-04, -4.037e-03]' }	{'[4.466e+02, -1.606e-01, -2.895e+01]' }
21	30	-0.002	{'Bottom'}	0.0026383	{'[3.659e-03, -1.777e-03, 7.807e-04]' }	{'[2.638e-03, -7.559e-04, -4.318e-03]' }	{'[4.775e+02, -1.775e-01, -3.096e+01]' }
22	0	-0.002	{'Top' }	0.0036593	{'[3.659e-03, -1.777e-03, 7.807e-04]' }	{'[3.659e-03, -1.777e-03, 7.807e-04]' }	{'[6.602e+02, -7.783e+00, 5.598e+00]' }
22	0	-0.002125	{'Bottom'}	0.0038962	{'[3.896e-03, -1.893e-03, 8.309e-04]' }	{'[3.896e-03, -1.893e-03, 8.309e-04]' }	{'[7.029e+02, -8.295e+00, 5.958e+00]' }

F_xx: 4.444e-07
F_x: 0.000e+00
F_yy: 1.016e-04
F_y: 2.093e-02
F_s: 1.113e-02
F_xy: -3.360e-06

Ply	Angle (deg)	z_height (m)	Surface	Sigma_x	Sigma_y	Sigma_s
1	0	0.002125	{'Top' }	-749.99	9.1044	-6.2809
1	0	0.002	{'Bottom'}	-707.26	8.5927	-5.9209
2	30	0.002	{'Top' }	-509.61	0.36342	33.359
2	30	0.001875	{'Bottom'}	-478.76	0.34652	31.349
3	-30	0.001875	{'Top' }	-358.59	-4.657	-36.91
3	-30	0.00175	{'Bottom'}	-335.52	-4.35	-34.541
4	45	0.00175	{'Top' }	-226.54	-8.8878	36.881
4	45	0.001625	{'Bottom'}	-210.86	-8.273	34.353
5	-45	0.001625	{'Top' }	-90.063	-13.303	-34.353
5	-45	0.0015	{'Bottom'}	-83.37	-12.314	-31.824
6	30	0.0015	{'Top' }	-386.22	0.2958	25.32
6	30	0.001375	{'Bottom'}	-355.38	0.2789	23.31
7	-30	0.001375	{'Top' }	-266.32	-3.4291	-27.431
7	-30	0.00125	{'Bottom'}	-243.25	-3.1222	-25.061
8	45	0.00125	{'Top' }	-163.84	-6.4285	26.767
8	45	0.001125	{'Bottom'}	-148.17	-5.8137	24.238
9	-45	0.001125	{'Top' }	-63.294	-9.3474	-24.238
9	-45	0.001	{'Bottom'}	-56.602	-8.3586	-21.709
10	90	0.001	{'Top' }	176.31	-18.056	3.0413
10	90	0.000875	{'Bottom'}	155.95	-15.941	2.6813
11	90	0.000875	{'Top' }	155.95	-15.941	2.6813
11	90	0.00075	{'Bottom'}	135.58	-13.825	2.3214
12	90	-0.00075	{'Top' }	-108.8	11.559	-1.9981
12	90	-0.000875	{'Bottom'}	-129.17	13.674	-2.358
13	90	-0.000875	{'Top' }	-129.17	13.674	-2.358
13	90	-0.001	{'Bottom'}	-149.53	15.79	-2.718
14	-45	-0.001	{'Top' }	50.474	7.4621	18.749
14	-45	-0.001125	{'Bottom'}	57.166	8.4508	21.277
15	45	-0.001125	{'Top' }	133.97	5.2531	-21.277
15	45	-0.00125	{'Bottom'}	149.64	5.8679	-23.806
16	-30	-0.00125	{'Top' }	218.11	3.0171	22.335
16	-30	-0.001375	{'Bottom'}	241.18	3.3241	24.705
17	30	-0.001375	{'Top' }	323.25	-0.093008	-20.907

17	30	-0.0015	{'Bottom'}	354.1	-0.10991	-22.917
18	-45	-0.0015	{'Top' }	77.242	11.417	28.863
18	-45	-0.001625	{'Bottom'}	83.935	12.406	31.392
19	45	-0.001625	{'Top' }	196.67	7.7123	-31.392
19	45	-0.00175	{'Bottom'}	212.34	8.3272	-33.92
20	-30	-0.00175	{'Top' }	310.38	4.245	31.815
20	-30	-0.001875	{'Bottom'}	333.45	4.5519	34.185
21	30	-0.001875	{'Top' }	446.64	-0.16063	-28.947
21	30	-0.002	{'Bottom'}	477.49	-0.17753	-30.957
22	0	-0.002	{'Top' }	660.16	-7.7832	5.5976
22	0	-0.002125	{'Bottom'}	702.89	-8.2949	5.9575

Ply	Angle (deg)	Surface	R_1	R_2	R_3	R_4	R_5
1	0	{'Top' }	"N/A"	2	"4.3935"	27.02	"1.5093"
1	0	{'Bottom'}	"N/A"	2.1209	"4.6551"	28.629	"1.6011"
2	30	{'Top' }	"N/A"	2.9434	"110.0648"	676.9	"N/A"
2	30	{'Bottom'}	"N/A"	3.1331	"115.4343"	709.92	"N/A"
3	-30	{'Top' }	"N/A"	4.183	"N/A"	52.824	"N/A"
3	-30	{'Bottom'}	"N/A"	4.4706	"N/A"	56.552	"N/A"
4	45	{'Top' }	"N/A"	6.6215	"N/A"	27.678	"N/A"
4	45	{'Bottom'}	"N/A"	7.1136	"N/A"	29.735	"N/A"
5	-45	{'Top' }	"N/A"	16.655	"N/A"	18.493	"N/A"
5	-45	{'Bottom'}	"N/A"	17.992	"N/A"	19.978	"N/A"
6	30	{'Top' }	"N/A"	3.8838	"135.2251"	831.63	"N/A"
6	30	{'Bottom'}	"N/A"	4.2209	"143.4215"	882.04	"N/A"
7	-30	{'Top' }	"N/A"	5.6323	"N/A"	71.739	"N/A"
7	-30	{'Bottom'}	"N/A"	6.1665	"N/A"	78.792	"N/A"
8	45	{'Top' }	"N/A"	9.1553	"N/A"	38.267	"N/A"
8	45	{'Bottom'}	"N/A"	10.124	"N/A"	42.314	"N/A"
9	-45	{'Top' }	"N/A"	23.699	"N/A"	26.318	"N/A"
9	-45	{'Bottom'}	"N/A"	26.501	"N/A"	29.431	"N/A"
10	90	{'Top' }	"8.5076"	8.5076	"N/A"	13.624	"3.1171"
10	90	{'Bottom'}	"9.6186"	9.6186	"N/A"	15.432	"3.5356"
11	90	{'Top' }	"9.6186"	9.6186	"N/A"	15.432	"3.5356"
11	90	{'Bottom'}	"11.0634"	11.063	"N/A"	17.793	"4.0838"
12	90	{'Top' }	"N/A"	13.786	"3.4606"	21.282	"4.7446"
12	90	{'Bottom'}	"N/A"	11.613	"2.9252"	17.99	"4.0203"
13	90	{'Top' }	"N/A"	11.613	"2.9252"	17.99	"4.0203"
13	90	{'Bottom'}	"N/A"	10.031	"2.5333"	15.58	"3.4879"
14	-45	{'Top' }	"29.7185"	29.719	"5.3605"	32.967	"N/A"
14	-45	{'Bottom'}	"26.2395"	26.239	"4.7333"	29.11	"N/A"

15	45	{'Top' }	"11.1966"	11.197	"7.6146"	46.83	"N/A"
15	45	{'Bottom'}	"10.0238"	10.024	"6.8168"	41.923	"N/A"
16	-30	{'Top' }	"6.8772"	6.8772	"13.2576"	81.534	"N/A"
16	-30	{'Bottom'}	"6.2194"	6.2194	"12.0334"	74.005	"N/A"
17	30	{'Top' }	"4.6403"	4.6403	"N/A"	2644.9	"N/A"
17	30	{'Bottom'}	"4.2361"	4.2361	"N/A"	2238.1	"N/A"
18	-45	{'Top' }	"19.4194"	19.419	"3.5035"	21.546	"N/A"
18	-45	{'Bottom'}	"17.8711"	17.871	"3.2242"	19.829	"N/A"
19	45	{'Top' }	"7.6271"	7.6271	"5.1865"	31.897	"N/A"
19	45	{'Bottom'}	"7.0641"	7.0641	"4.8036"	29.542	"N/A"
20	-30	{'Top' }	"4.8327"	4.8327	"9.4229"	57.951	"N/A"
20	-30	{'Bottom'}	"4.4984"	4.4984	"8.7874"	54.043	"N/A"
21	30	{'Top' }	"3.3584"	3.3584	"N/A"	1531.5	"N/A"
21	30	{'Bottom'}	"3.1415"	3.1415	"N/A"	1385.7	"N/A"
22	0	{'Top' }	"2.2722"	2.2722	"N/A"	31.607	"1.6936"
22	0	{'Bottom'}	"2.134"	2.134	"N/A"	29.657	"1.5913"

Ply	Angle (deg)	Surface	R_quadratic_1	R_quadratic_2
1	0	{'Top' }	1.0388	-1.2952
1	0	{'Bottom'}	1.1016	-1.3738
2	30	{'Top' }	0.28255	-0.28315
2	30	{'Bottom'}	0.30066	-0.30131
3	-30	{'Top' }	0.25966	-0.25325
3	-30	{'Bottom'}	0.27747	-0.27063
4	45	{'Top' }	0.26311	-0.25083
4	45	{'Bottom'}	0.28247	-0.2693
5	-45	{'Top' }	0.28662	-0.26543
5	-45	{'Bottom'}	0.30938	-0.28653
6	30	{'Top' }	0.37223	-0.37309
6	30	{'Bottom'}	0.40432	-0.40528
7	-30	{'Top' }	0.34935	-0.3408
7	-30	{'Bottom'}	0.38237	-0.37304
8	45	{'Top' }	0.3625	-0.34564
8	45	{'Bottom'}	0.40031	-0.38171
9	-45	{'Top' }	0.40616	-0.37625
9	-45	{'Bottom'}	0.45344	-0.42011
10	90	{'Top' }	3.76	-1.5529
10	90	{'Bottom'}	4.2623	-1.7595
11	90	{'Top' }	4.2623	-1.7595
11	90	{'Bottom'}	4.9195	-2.0296
12	90	{'Top' }	2.4105	-5.7848

Ply	Angle (deg)	Surface		
12	90	{'Bottom'}	2.0388	-4.897
13	90	{'Top' }	2.0388	-4.897
13	90	{'Bottom'}	1.7665	-4.2455
14	-45	{'Top' }	0.48581	-0.5257
14	-45	{'Bottom'}	0.42811	-0.46319
15	45	{'Top' }	0.43451	-0.45632
15	45	{'Bottom'}	0.38837	-0.40783
16	-30	{'Top' }	0.41813	-0.42947
16	-30	{'Bottom'}	0.37804	-0.38826
17	30	{'Top' }	0.45147	-0.45107
17	30	{'Bottom'}	0.41189	-0.4115
18	-45	{'Top' }	0.31564	-0.3414
18	-45	{'Bottom'}	0.29023	-0.31389
19	45	{'Top' }	0.29455	-0.30925
19	45	{'Bottom'}	0.2726	-0.2862
20	-30	{'Top' }	0.2936	-0.30146
20	-30	{'Bottom'}	0.27325	-0.28056
21	30	{'Top' }	0.32612	-0.32576
21	30	{'Bottom'}	0.30495	-0.30461
22	0	{'Top' }	1.4568	-1.1773
22	0	{'Bottom'}	1.3687	-1.1059

Ply	Angle (deg)	Surface	R_hashin_1	R_hashin_2	R_hashin_3	R_hashin_4
1	0	{'Top' }	"N/A"	"2"	"1.4275"	"N/A"
1	0	{'Bottom'}	"N/A"	"2.1209"	"1.5141"	"N/A"
2	30	{'Top' }	"N/A"	"2.9434"	"0.28418"	"N/A"
2	30	{'Bottom'}	"N/A"	"3.1331"	"0.3024"	"N/A"
3	-30	{'Top' }	"N/A"	"4.183"	"N/A"	"0.28806"
3	-30	{'Bottom'}	"N/A"	"4.4706"	"N/A"	"0.31055"
4	45	{'Top' }	"N/A"	"6.6215"	"N/A"	"0.32775"
4	45	{'Bottom'}	"N/A"	"7.1136"	"N/A"	"0.36052"
5	-45	{'Top' }	"N/A"	"16.6551"	"N/A"	"0.46756"
5	-45	{'Bottom'}	"N/A"	"17.992"	"N/A"	"0.54928"
6	30	{'Top' }	"N/A"	"3.8838"	"0.37441"	"N/A"
6	30	{'Bottom'}	"N/A"	"4.2209"	"0.40669"	"N/A"
7	-30	{'Top' }	"N/A"	"5.6323"	"N/A"	"0.40579"
7	-30	{'Bottom'}	"N/A"	"6.1665"	"N/A"	"0.45213"
8	45	{'Top' }	"N/A"	"9.1553"	"N/A"	"0.51889"
8	45	{'Bottom'}	"N/A"	"10.1238"	"N/A"	"0.61128"
9	-45	{'Top' }	"N/A"	"23.699"	"N/A"	"1.5404"
9	-45	{'Bottom'}	"N/A"	"26.501"	"N/A"	"0-2.0104i"

10	90	{'Top' }	"2.9268"	"N/A"	"N/A"	"0-0.29784i"
10	90	{'Bottom'}	"3.3185"	"N/A"	"N/A"	"0-0.31533i"
11	90	{'Top' }	"3.3185"	"N/A"	"N/A"	"0-0.31533i"
11	90	{'Bottom'}	"3.8311"	"N/A"	"N/A"	"0-0.33685i"
12	90	{'Top' }	"N/A"	"13.7864"	"2.7959"	"N/A"
12	90	{'Bottom'}	"N/A"	"11.6127"	"2.3654"	"N/A"
13	90	{'Top' }	"N/A"	"11.6127"	"2.3654"	"N/A"
13	90	{'Bottom'}	"N/A"	"10.0312"	"2.0497"	"N/A"
14	-45	{'Top' }	"0.50556"	"N/A"	"0.5034"	"N/A"
14	-45	{'Bottom'}	"0.44548"	"N/A"	"0.44359"	"N/A"
15	45	{'Top' }	"0.44519"	"N/A"	"0.44479"	"N/A"
15	45	{'Bottom'}	"0.39791"	"N/A"	"0.39754"	"N/A"
16	-30	{'Top' }	"0.42363"	"N/A"	"0.42422"	"N/A"
16	-30	{'Bottom'}	"0.383"	"N/A"	"0.38353"	"N/A"
17	30	{'Top' }	"0.45128"	"N/A"	"N/A"	"0.4564"
17	30	{'Bottom'}	"0.4117"	"N/A"	"N/A"	"0.41633"
18	-45	{'Top' }	"0.3284"	"N/A"	"0.32701"	"N/A"
18	-45	{'Bottom'}	"0.30195"	"N/A"	"0.30067"	"N/A"
19	45	{'Top' }	"0.30175"	"N/A"	"0.30148"	"N/A"
19	45	{'Bottom'}	"0.27926"	"N/A"	"0.27901"	"N/A"
20	-30	{'Top' }	"0.29741"	"N/A"	"0.29783"	"N/A"
20	-30	{'Bottom'}	"0.27679"	"N/A"	"0.27718"	"N/A"
21	30	{'Top' }	"0.32595"	"N/A"	"N/A"	"0.32943"
21	30	{'Bottom'}	"0.30479"	"N/A"	"N/A"	"0.30798"
22	0	{'Top' }	"1.3579"	"N/A"	"N/A"	"0-0.45751i"
22	0	{'Bottom'}	"1.2757"	"N/A"	"N/A"	"0-0.44472i"

First failure occurs in Ply 1 at 0.000 degrees on the Top surface.
Smallest R value (failure): R = 2.000
Failure Mode: Fiber Compression
M_i * R = [-1982.022; -198.002; -210.002] Nm
N_i * R = [-45000.498; 6200.069; -4000.044] N

================= QUADRATIC CRITERION CONCLUSIONS =================
First failure occurs in Ply 3 at -30.000 degrees on the Top surface.
Smallest R value (failure): R = 0.260
M_i * R = [-257.320; -25.706; -27.264] Nm
N_i * R = [-5842.289; 804.938; -519.315] N

================= HASHIN CRITERION CONCLUSIONS =================
First failure occurs in Ply 20 at -30.000 degrees on the Bottom surface.
Smallest R value (failure): R = 0.277
Failure Mode: Fiber Tension

M_i * R = [-274.299; -27.402; -29.063] Nm
N_i * R = [-6227.775; 858.049; -553.580] N
Results of evaluateLaminate:

Maximum Stress Reserve Minimum: 2.0000
Quadratic Reserve Minimum: 0.2597
Hashin Reserve Minimum: 0.2768
Mass of Laminate: 88.0000 g

Program Output for Load 2:

Ply	Angle (deg)	z_height (m)	Surface	Epsilon_x	epsilon_vector	on_axis_strain	on_axis_stress
1	0	0.002125	{'Top' }	-0.0039636	{'[-3.964e-03, 1.921e-03, -9.956e-04]'}	{'[-3.964e-03, 1.921e-03, -9.956e-04]' }	{'[-7.151e+02, 8.394e+00, -7.138e+00]' }
1	0	0.002	{'Bottom'}	-0.0037368	{'[-3.737e-03, 1.810e-03, -9.385e-04]'}	{'[-3.737e-03, 1.810e-03, -9.385e-04]' }	{'[-6.741e+02, 7.901e+00, -6.729e+00]' }
2	30	0.002	{'Top' }	-0.0027565	{'[-3.737e-03, 1.810e-03, -9.385e-04]'}	{'[-2.756e-03, 8.297e-04, 4.334e-03]' }	{'[-4.988e+02, 5.985e-01, 3.108e+01]' }
2	30	0.001875	{'Bottom'}	-0.0025894	{'[-3.510e-03, 1.699e-03, -8.814e-04]'}	{'[-2.589e-03, 7.783e-04, 4.070e-03]' }	{'[-4.685e+02, 5.506e-01, 2.918e+01]' }
3	-30	0.001875	{'Top' }	-0.0018261	{'[-3.510e-03, 1.699e-03, -8.814e-04]'}	{'[-1.826e-03, 1.490e-05, -4.952e-03]' }	{'[-3.320e+02, -5.136e+00, -3.550e+01]'}
3	-30	0.00175	{'Bottom'}	-0.0017084	{'[-3.283e-03, 1.588e-03, -8.244e-04]'}	{'[-1.708e-03, 1.293e-05, -4.630e-03]' }	{'[-3.106e+02, -4.815e+00, -3.320e+01]'}
4	45	0.00175	{'Top' }	-0.0012599	{'[-3.283e-03, 1.588e-03, -8.244e-04]'}	{'[-1.260e-03, -4.356e-04, 4.871e-03]' }	{'[-2.303e+02, -8.156e+00, 3.492e+01]' }
4	45	0.001625	{'Bottom'}	-0.0011736	{'[-3.056e-03, 1.476e-03, -7.673e-04]'}	{'[-1.174e-03, -4.063e-04, 4.532e-03]' }	{'[-2.145e+02, -7.603e+00, 3.250e+01]' }
5	-45	0.001625	{'Top' }	-0.00040627	{'[-3.056e-03, 1.476e-03, -7.673e-04]'}	{'[-4.063e-04, -1.174e-03, -4.532e-03]'}	{'[-7.726e+01, -1.332e+01, -3.250e+01]'}
5	-45	0.0015	{'Bottom'}	-0.00037697	{'[-2.829e-03, 1.365e-03, -7.102e-04]'}	{'[-3.770e-04, -1.087e-03, -4.194e-03]'}	{'[-7.169e+01, -1.234e+01, -3.007e+01]'}
6	30	0.0015	{'Top' }	-0.0020882	{'[-2.829e-03, 1.365e-03, -7.102e-04]'}	{'[-2.088e-03, 6.241e-04, 3.277e-03]' }	{'[-3.779e+02, 4.071e-01, 2.350e+01]' }
6	30	0.001375	{'Bottom'}	-0.0019212	{'[-2.602e-03, 1.254e-03, -6.532e-04]'}	{'[-1.921e-03, 5.727e-04, 3.013e-03]' }	{'[-3.476e+02, 3.593e-01, 2.160e+01]' }
7	-30	0.001375	{'Top' }	-0.0013555	{'[-2.602e-03, 1.254e-03, -6.532e-04]'}	{'[-1.356e-03, 7.002e-06, -3.666e-03]' }	{'[-2.464e+02, -3.854e+00, -2.629e+01]'}
7	-30	0.00125	{'Bottom'}	-0.0012379	{'[-2.376e-03, 1.143e-03, -5.961e-04]'}	{'[-1.238e-03, 5.027e-06, -3.345e-03]' }	{'[-2.250e+02, -3.534e+00, -2.398e+01]'}
8	45	0.00125	{'Top' }	-0.00091447	{'[-2.376e-03, 1.143e-03, -5.961e-04]'}	{'[-9.145e-04, -3.184e-04, 3.518e-03]' }	{'[-1.672e+02, -5.943e+00, 2.523e+01]' }
8	45	0.001125	{'Bottom'}	-0.0008281	{'[-2.149e-03, 1.031e-03, -5.390e-04]'}	{'[-8.281e-04, -2.891e-04, 3.180e-03]' }	{'[-1.514e+02, -5.390e+00, 2.280e+01]' }
9	-45	0.001125	{'Top' }	-0.00028909	{'[-2.149e-03, 1.031e-03, -5.390e-04]'}	{'[-2.891e-04, -8.281e-04, -3.180e-03]'}	{'[-5.496e+01, -9.405e+00, -2.280e+01]'}
9	-45	0.001	{'Bottom'}	-0.00025979	{'[-1.922e-03, 9.203e-04, -4.819e-04]'}	{'[-2.598e-04, -7.417e-04, -2.842e-03]'}	{'[-4.938e+01, -8.427e+00, -2.038e+00]'}
10	90	0.001	{'Top' }	0.00092029	{'[-1.922e-03, 9.203e-04, -4.819e-04]'}	{'[9.203e-04, -1.922e-03, 4.819e-04]' }	{'[1.618e+02, -1.722e+01, 3.456e+00]' }
10	90	0.000875	{'Bottom'}	0.00080908	{'[-1.695e-03, 8.091e-04, -4.249e-04]'}	{'[8.091e-04, -1.695e-03, 4.249e-04]' }	{'[1.422e+02, -1.519e+01, 3.046e+00]' }
11	90	0.000875	{'Top' }	0.00080908	{'[-1.695e-03, 8.091e-04, -4.249e-04]'}	{'[8.091e-04, -1.695e-03, 4.249e-04]' }	{'[1.422e+02, -1.519e+01, 3.046e+00]' }
11	90	0.00075	{'Bottom'}	0.00069788	{'[-1.468e-03, 6.979e-04, -3.678e-04]'}	{'[6.979e-04, -1.468e-03, 3.678e-04]' }	{'[1.226e+02, -1.317e+01, 2.637e+00]' }
12	90	-0.00075	{'Top' }	-0.0006366	{'[1.254e-03, -6.366e-04, 3.171e-04]' }	{'[-6.366e-04, 1.254e-03, -3.171e-04]' }	{'[-1.121e+02, 1.113e+01, -2.273e+00]' }
12	90	-0.000875	{'Bottom'}	-0.0007478	{'[1.481e-03, -7.478e-04, 3.741e-04]' }	{'[-7.478e-04, 1.481e-03, -3.741e-04]' }	{'[-1.317e+02, 1.316e+01, -2.683e+00]' }
13	90	-0.000875	{'Top' }	-0.0007478	{'[1.481e-03, -7.478e-04, 3.741e-04]' }	{'[-7.478e-04, 1.481e-03, -3.741e-04]' }	{'[-1.317e+02, 1.316e+01, -2.683e+00]' }
13	90	-0.001	{'Bottom'}	-0.00085901	{'[1.708e-03, -8.590e-04, 4.312e-04]' }	{'[-8.590e-04, 1.708e-03, -4.312e-04]' }	{'[-1.512e+02, 1.518e+01, -3.092e+00]' }
14	-45	-0.001	{'Top' }	0.00020892	{'[1.708e-03, -8.590e-04, 4.312e-04]' }	{'[2.089e-04, 6.401e-04, 2.567e-03]' }	{'[3.984e+01, 7.228e+00, 1.841e+01]' }
14	-45	-0.001125	{'Bottom'}	0.00023821	{'[1.935e-03, -9.702e-04, 4.883e-04]' }	{'[2.382e-04, 7.265e-04, 2.905e-03]' }	{'[4.541e+01, 8.206e+00, 2.083e+01]' }
15	45	-0.001125	{'Top' }	0.00072649	{'[1.935e-03, -9.702e-04, 4.883e-04]' }	{'[7.265e-04, 2.382e-04, -2.905e-03]' }	{'[1.328e+02, 4.569e+00, -2.083e+01]' }
15	45	-0.00125	{'Bottom'}	0.00081286	{'[2.162e-03, -1.081e-03, 5.454e-04]' }	{'[8.129e-04, 2.675e-04, -3.243e-03]' }	{'[1.486e+02, 5.122e+00, -2.325e+01]' }
16	-30	-0.00125	{'Top' }	0.0011148	{'[2.162e-03, -1.081e-03, 5.454e-04]' }	{'[1.115e-03, -3.448e-05, 3.081e-03]' }	{'[2.026e+02, 2.873e+00, 2.209e+01]' }
16	-30	-0.001375	{'Bottom'}	0.0012325	{'[2.389e-03, -1.193e-03, 6.024e-04]' }	{'[1.232e-03, -3.645e-05, 3.403e-03]' }	{'[2.240e+02, 3.193e+00, 2.440e+01]' }
17	30	-0.001375	{'Top' }	0.0017542	{'[2.389e-03, -1.193e-03, 6.024e-04]' }	{'[1.754e-03, -5.582e-04, -2.800e-03]' }	{'[3.173e+02, -6.931e-01, -2.008e+01]'}
17	30	-0.0015	{'Bottom'}	0.0019213	{'[2.616e-03, -1.304e-03, 6.595e-04]' }	{'[1.921e-03, -6.096e-04, -3.065e-03]' }	{'[3.475e+02, -7.410e-01, -2.197e+01]'}
18	-45	-0.0015	{'Top' }	0.00032609	{'[2.616e-03, -1.304e-03, 6.595e-04]' }	{'[3.261e-04, 9.856e-04, 3.919e-03]' }	{'[6.214e+01, 1.114e+01, 2.810e+01]' }
18	-45	-0.001625	{'Bottom'}	0.00035539	{'[2.842e-03, -1.415e-03, 7.166e-04]' }	{'[3.554e-04, 1.072e-03, 4.257e-03]' }	{'[6.772e+01, 1.212e+01, 3.053e+01]' }
19	45	-0.001625	{'Top' }	0.001072	{'[2.842e-03, -1.415e-03, 7.166e-04]' }	{'[1.072e-03, 3.554e-04, -4.257e-03]' }	{'[1.959e+02, 6.782e+00, -3.053e+01]'}
19	45	-0.00175	{'Bottom'}	0.0011583	{'[3.069e-03, -1.526e-03, 7.736e-04]' }	{'[1.158e-03, 3.847e-04, -4.596e-03]' }	{'[2.117e+02, 7.336e+00, -3.295e+01]'}
20	-30	-0.00175	{'Top' }	0.0015854	{'[3.069e-03, -1.526e-03, 7.736e-04]' }	{'[1.585e-03, -4.238e-05, 4.367e-03]' }	{'[2.881e+02, 4.154e+00, 3.131e+01]' }
20	-30	-0.001875	{'Bottom'}	0.001703	{'[3.296e-03, -1.637e-03, 8.307e-04]' }	{'[1.703e-03, -4.435e-05, 4.688e-03]' }	{'[3.095e+02, 4.475e+00, 3.361e+01]' }
21	30	-0.001875	{'Top' }	0.0024224	{'[3.296e-03, -1.637e-03, 8.307e-04]' }	{'[2.422e-03, -7.638e-04, -3.857e-03]' }	{'[4.382e+02, -8.845e-01, -2.766e+01]'}
21	30	-0.002	{'Bottom'}	0.0025895	{'[3.523e-03, -1.749e-03, 8.878e-04]' }	{'[2.589e-03, -8.152e-04, -4.121e-03]' }	{'[4.684e+02, -9.323e-01, -2.955e+01]'}
22	0	-0.002	{'Top' }	0.003523	{'[3.523e-03, -1.749e-03, 8.878e-04]' }	{'[3.523e-03, -1.749e-03, 8.878e-04]' }	{'[6.355e+02, -7.886e+00, 6.365e+00]' }
22	0	-0.002125	{'Bottom'}	0.0037499	{'[3.750e-03, -1.860e-03, 9.449e-04]' }	{'[3.750e-03, -1.860e-03, 9.449e-04]' }	{'[6.764e+02, -8.379e+00, 6.775e+00]' }

F_xx: 4.444e-07

```
F_x:  0.000e+00
F_yy: 1.016e-04
F_y:  2.093e-02
F_s:  1.113e-02
F_xy: -3.360e-06
```

Ply	Angle (deg)	z_height (m)	Surface	Sigma_x	Sigma_y	Sigma_s
1	0	0.002125	{'Top' }	-715.07	8.3942	-7.1384
1	0	0.002	{'Bottom'}	-674.14	7.9008	-6.7291
2	30	0.002	{'Top' }	-498.75	0.59846	31.077
2	30	0.001875	{'Bottom'}	-468.53	0.55062	29.182
3	-30	0.001875	{'Top' }	-331.95	-5.1358	-35.502
3	-30	0.00175	{'Bottom'}	-310.57	-4.8154	-33.199
4	45	0.00175	{'Top' }	-230.33	-8.1563	34.922
4	45	0.001625	{'Bottom'}	-214.54	-7.603	32.498
5	-45	0.001625	{'Top' }	-77.264	-13.319	-32.498
5	-45	0.0015	{'Bottom'}	-71.687	-12.34	-30.074
6	30	0.0015	{'Top' }	-377.85	0.40711	23.499
6	30	0.001375	{'Bottom'}	-347.63	0.35928	21.604
7	-30	0.001375	{'Top' }	-246.43	-3.8544	-26.287
7	-30	0.00125	{'Bottom'}	-225.05	-3.534	-23.983
8	45	0.00125	{'Top' }	-167.18	-5.9432	25.226
8	45	0.001125	{'Bottom'}	-151.4	-5.3899	22.802
9	-45	0.001125	{'Top' }	-54.959	-9.4051	-22.802
9	-45	0.001	{'Bottom'}	-49.382	-8.4267	-20.378
10	90	0.001	{'Top' }	161.75	-17.217	3.4555
10	90	0.000875	{'Bottom'}	142.19	-15.192	3.0463
11	90	0.000875	{'Top' }	142.19	-15.192	3.0463
11	90	0.00075	{'Bottom'}	122.63	-13.167	2.6371
12	90	-0.00075	{'Top' }	-112.11	11.133	-2.2734
12	90	-0.000875	{'Bottom'}	-131.67	13.158	-2.6826
13	90	-0.000875	{'Top' }	-131.67	13.158	-2.6826
13	90	-0.001	{'Bottom'}	-151.23	15.183	-3.0918
14	-45	-0.001	{'Top' }	39.838	7.228	18.406
14	-45	-0.001125	{'Bottom'}	45.414	8.2065	20.83
15	45	-0.001125	{'Top' }	132.77	4.5692	-20.83
15	45	-0.00125	{'Bottom'}	148.56	5.1224	-23.254
16	-30	-0.00125	{'Top' }	202.59	2.8729	22.093
16	-30	-0.001375	{'Bottom'}	223.97	3.1933	24.397
17	30	-0.001375	{'Top' }	317.31	-0.69313	-20.078
17	30	-0.0015	{'Bottom'}	347.54	-0.74096	-21.973
18	-45	-0.0015	{'Top' }	62.143	11.142	28.102

Ply	Angle (deg)	Surface				
18	-45	{'Bottom'}	-0.001625	67.719	12.12	30.526
19	45	{'Top' }	-0.001625	195.92	6.7823	-30.526
19	45	{'Bottom'}	-0.00175	211.71	7.3356	-32.95
20	-30	{'Top' }	-0.00175	288.12	4.1543	31.309
20	-30	{'Bottom'}	-0.001875	309.5	4.4746	33.613
21	30	{'Top' }	-0.001875	438.21	-0.88447	-27.656
21	30	{'Bottom'}	-0.002	468.44	-0.93231	-29.551
22	0	{'Top' }	-0.002	635.45	-7.8861	6.3654
22	0	{'Bottom'}	-0.002125	676.38	-8.3794	6.7746

Ply	Angle (deg)	Surface	R_1	R_2	R_3	R_4	R_5
1	0	{'Top' }	"N/A"	2.0977	"4.7652"	29.306	"1.328"
1	0	{'Bottom'}	"N/A"	2.2251	"5.0628"	31.136	"1.4088"
2	30	{'Top' }	"N/A"	3.0075	"66.8384"	411.06	"N/A"
2	30	{'Bottom'}	"N/A"	3.2015	"72.6451"	446.77	"N/A"
3	-30	{'Top' }	"N/A"	4.5187	"N/A"	47.899	"N/A"
3	-30	{'Bottom'}	"N/A"	4.8298	"N/A"	51.086	"N/A"
4	45	{'Top' }	"N/A"	6.5124	"N/A"	30.161	"N/A"
4	45	{'Bottom'}	"N/A"	6.9916	"N/A"	32.355	"N/A"
5	-45	{'Top' }	"N/A"	19.414	"N/A"	18.47	"N/A"
5	-45	{'Bottom'}	"N/A"	20.924	"N/A"	19.935	"N/A"
6	30	{'Top' }	"N/A"	3.9698	"98.253"	604.26	"N/A"
6	30	{'Bottom'}	"N/A"	4.3149	"111.3351"	684.71	"N/A"
7	-30	{'Top' }	"N/A"	6.087	"N/A"	63.824	"N/A"
7	-30	{'Bottom'}	"N/A"	6.6653	"N/A"	69.609	"N/A"
8	45	{'Top' }	"N/A"	8.9722	"N/A"	41.392	"N/A"
8	45	{'Bottom'}	"N/A"	9.9078	"N/A"	45.641	"N/A"
9	-45	{'Top' }	"N/A"	27.293	"N/A"	26.156	"N/A"
9	-45	{'Bottom'}	"N/A"	30.375	"N/A"	29.193	"N/A"
10	90	{'Top' }	"9.2735"	9.2735	"N/A"	14.288	"2.7434"
10	90	{'Bottom'}	"10.5492"	10.549	"N/A"	16.192	"3.112"
11	90	{'Top' }	"10.5492"	10.549	"N/A"	16.192	"3.112"
11	90	{'Bottom'}	"12.232"	12.232	"N/A"	18.683	"3.5949"
12	90	{'Top' }	"N/A"	13.38	"3.5929"	22.096	"4.17"
12	90	{'Bottom'}	"N/A"	11.392	"3.0399"	18.696	"3.5339"
13	90	{'Top' }	"N/A"	11.392	"3.0399"	18.696	"3.5339"
13	90	{'Bottom'}	"N/A"	9.9187	"2.6345"	16.202	"3.0662"
14	-45	{'Top' }	"37.6529"	37.653	"5.534"	34.034	"N/A"
14	-45	{'Bottom'}	"33.0296"	33.03	"4.8742"	29.976	"N/A"
15	45	{'Top' }	"11.2974"	11.297	"8.7544"	53.839	"N/A"
15	45	{'Bottom'}	"10.0968"	10.097	"7.8088"	48.024	"N/A"

16	-30	{'Top' }	"7.4041"	7.4041	"13.9232"	85.628	"N/A"
16	-30	{'Bottom'}	"6.6973"	6.6973	"12.5264"	77.037	"N/A"
17	30	{'Top' }	"4.7272"	4.7272	"N/A"	354.91	"N/A"
17	30	{'Bottom'}	"4.3161"	4.3161	"N/A"	332	"N/A"
18	-45	{'Top' }	"24.138"	24.138	"3.5901"	22.079	"N/A"
18	-45	{'Bottom'}	"22.1504"	22.15	"3.3003"	20.297	"N/A"
19	45	{'Top' }	"7.6561"	7.6561	"5.8977"	36.271	"N/A"
19	45	{'Bottom'}	"7.0852"	7.0852	"5.4529"	33.535	"N/A"
20	-30	{'Top' }	"5.2062"	5.2062	"9.6286"	59.216	"N/A"
20	-30	{'Bottom'}	"4.8465"	4.8465	"8.9393"	54.977	"N/A"
21	30	{'Top' }	"3.423"	3.423	"N/A"	278.13	"N/A"
21	30	{'Bottom'}	"3.2021"	3.2021	"N/A"	263.86	"N/A"
22	0	{'Top' }	"2.3605"	2.3605	"N/A"	31.194	"1.4893"
22	0	{'Bottom'}	"2.2177"	2.2177	"N/A"	29.358	"1.3993"

Ply	Angle (deg)	Surface	R_quadratic_1	R_quadratic_2
1	0	{'Top' }	0.99056	-1.1993
1	0	{'Bottom'}	1.051	-1.2721
2	30	{'Top' }	0.30289	-0.30404
2	30	{'Bottom'}	0.32256	-0.32377
3	-30	{'Top' }	0.27049	-0.26285
3	-30	{'Bottom'}	0.28927	-0.28108
4	45	{'Top' }	0.27764	-0.26508
4	45	{'Bottom'}	0.29836	-0.28484
5	-45	{'Top' }	0.30363	-0.27993
5	-45	{'Bottom'}	0.32812	-0.30248
6	30	{'Top' }	0.40064	-0.40201
6	30	{'Bottom'}	0.43581	-0.43724
7	-30	{'Top' }	0.36539	-0.35492
7	-30	{'Bottom'}	0.40051	-0.38899
8	45	{'Top' }	0.38443	-0.36688
8	45	{'Bottom'}	0.42533	-0.40585
9	-45	{'Top' }	0.43285	-0.39886
9	-45	{'Bottom'}	0.48439	-0.44626
10	90	{'Top' }	3.3901	-1.5257
10	90	{'Bottom'}	3.8475	-1.7302
11	90	{'Top' }	3.8475	-1.7302
11	90	{'Bottom'}	4.4475	-1.998
12	90	{'Top' }	2.3308	-5.1029
12	90	{'Bottom'}	1.9743	-4.3284
13	90	{'Top' }	1.9743	-4.3284

Ply	Angle (deg)	Surface		
13	90	{'Bottom'}	1.7125	-3.758
14	-45	{'Top' }	0.49512	-0.53521
14	-45	{'Bottom'}	0.43744	-0.47299
15	45	{'Top' }	0.44505	-0.46484
15	45	{'Bottom'}	0.39862	-0.41642
16	-30	{'Top' }	0.423	-0.43404
16	-30	{'Bottom'}	0.38303	-0.39309
17	30	{'Top' }	0.47135	-0.46815
17	30	{'Bottom'}	0.43067	-0.42781
18	-45	{'Top' }	0.32416	-0.35068
18	-45	{'Bottom'}	0.2984	-0.32285
19	45	{'Top' }	0.3036	-0.31728
19	45	{'Bottom'}	0.28125	-0.29395
20	-30	{'Top' }	0.29842	-0.30637
20	-30	{'Bottom'}	0.27795	-0.28538
21	30	{'Top' }	0.3421	-0.33994
21	30	{'Bottom'}	0.32015	-0.31816
22	0	{'Top' }	1.3507	-1.1044
22	0	{'Bottom'}	1.269	-1.0379

Ply	Angle (deg)	Surface	R_hashin_1	R_hashin_2	R_hashin_3	R_hashin_4
1	0	{'Top' }	"N/A"	"2.0977"	"1.2793"	"N/A"
1	0	{'Bottom'}	"N/A"	"2.2251"	"1.3572"	"N/A"
2	30	{'Top' }	"N/A"	"3.0075"	"0.30504"	"N/A"
2	30	{'Bottom'}	"N/A"	"3.2015"	"0.32485"	"N/A"
3	-30	{'Top' }	"N/A"	"4.5187"	"N/A"	"0.30708"
3	-30	{'Bottom'}	"N/A"	"4.8298"	"N/A"	"0.33237"
4	45	{'Top' }	"N/A"	"6.5124"	"N/A"	"0.34907"
4	45	{'Bottom'}	"N/A"	"6.9916"	"N/A"	"0.38518"
5	-45	{'Top' }	"N/A"	"19.4141"	"N/A"	"0.56035"
5	-45	{'Bottom'}	"N/A"	"20.9242"	"N/A"	"0.69125"
6	30	{'Top' }	"N/A"	"3.9698"	"0.40343"	"N/A"
6	30	{'Bottom'}	"N/A"	"4.3149"	"0.43881"	"N/A"
7	-30	{'Top' }	"N/A"	"6.087"	"N/A"	"0.44245"
7	-30	{'Bottom'}	"N/A"	"6.6653"	"N/A"	"0.49807"
8	45	{'Top' }	"N/A"	"8.9722"	"N/A"	"0.56468"
8	45	{'Bottom'}	"N/A"	"9.9078"	"N/A"	"0.67426"
9	-45	{'Top' }	"N/A"	"27.2933"	"N/A"	"0-1.6518i"
9	-45	{'Bottom'}	"N/A"	"30.3752"	"N/A"	"0-1.0459i"
10	90	{'Top' }	"2.6307"	"N/A"	"N/A"	"0-0.30493i"
10	90	{'Bottom'}	"2.9848"	"N/A"	"N/A"	"0-0.32293i"

11	90	{'Top' }	"2.9848"	"N/A"	"N/A"	"0-0.32293i"
11	90	{'Bottom'}	"3.449"	"N/A"	"N/A"	"0-0.34509i"
12	90	{'Top' }	"N/A"	"13.3801"	"2.7219"	"N/A"
12	90	{'Bottom'}	"N/A"	"11.3923"	"2.3046"	"N/A"
13	90	{'Top' }	"N/A"	"11.3923"	"2.3046"	"N/A"
13	90	{'Bottom'}	"N/A"	"9.9187"	"1.9982"	"N/A"
14	-45	{'Top' }	"0.51501"	"N/A"	"0.51284"	"N/A"
14	-45	{'Bottom'}	"0.45507"	"N/A"	"0.45315"	"N/A"
15	45	{'Top' }	"0.45475"	"N/A"	"0.4545"	"N/A"
15	45	{'Bottom'}	"0.40734"	"N/A"	"0.40712"	"N/A"
16	-30	{'Top' }	"0.42837"	"N/A"	"0.42888"	"N/A"
16	-30	{'Bottom'}	"0.38791"	"N/A"	"0.38838"	"N/A"
17	30	{'Top' }	"0.46982"	"N/A"	"N/A"	"0.49904"
17	30	{'Bottom'}	"0.42931"	"N/A"	"N/A"	"0.45316"
18	-45	{'Top' }	"0.33731"	"N/A"	"0.33587"	"N/A"
18	-45	{'Bottom'}	"0.31053"	"N/A"	"0.30919"	"N/A"
19	45	{'Top' }	"0.3103"	"N/A"	"0.31013"	"N/A"
19	45	{'Bottom'}	"0.28747"	"N/A"	"0.28731"	"N/A"
20	-30	{'Top' }	"0.30228"	"N/A"	"0.30264"	"N/A"
20	-30	{'Bottom'}	"0.28156"	"N/A"	"0.2819"	"N/A"
21	30	{'Top' }	"0.34107"	"N/A"	"N/A"	"0.35553"
21	30	{'Bottom'}	"0.3192"	"N/A"	"N/A"	"0.33177"
22	0	{'Top' }	"1.2596"	"N/A"	"N/A"	"0-0.45928i"
22	0	{'Bottom'}	"1.1834"	"N/A"	"N/A"	"0-0.44748i"

First failure occurs in Ply 1 at 0.000 degrees on the Top surface.
Smallest R value (failure): R = 2.098
Failure Mode: Fiber Compression
M_i * R = [-1992.825; -199.282; -241.237] Nm
N_i * R = [-43632.374; -6083.360; -4719.848] N

================= QUADRATIC CRITERION CONCLUSIONS =================
First failure occurs in Ply 3 at -30.000 degrees on the Top surface.
Smallest R value (failure): R = 0.270
M_i * R = [-256.967; -25.697; -31.107] Nm
N_i * R = [-5626.230; -784.426; -608.607] N

================= HASHIN CRITERION CONCLUSIONS =================
First failure occurs in Ply 20 at -30.000 degrees on the Bottom surface.
Smallest R value (failure): R = 0.282
Failure Mode: Fiber Tension
M_i * R = [-267.482; -26.748; -32.379] Nm
N_i * R = [-5856.448; -816.524; -633.510] N

```
Results of evaluateLaminate:
---------------------------------
Maximum Stress Reserve Minimum: 2.0977
Quadratic Reserve Minimum: 0.2705
Hashin Reserve Minimum: 0.2816
Mass of Laminate: 88.0000 g
```

Summary:

Number of layers: 22
Material Chosen: Graphite Epoxy (AS/H3501)
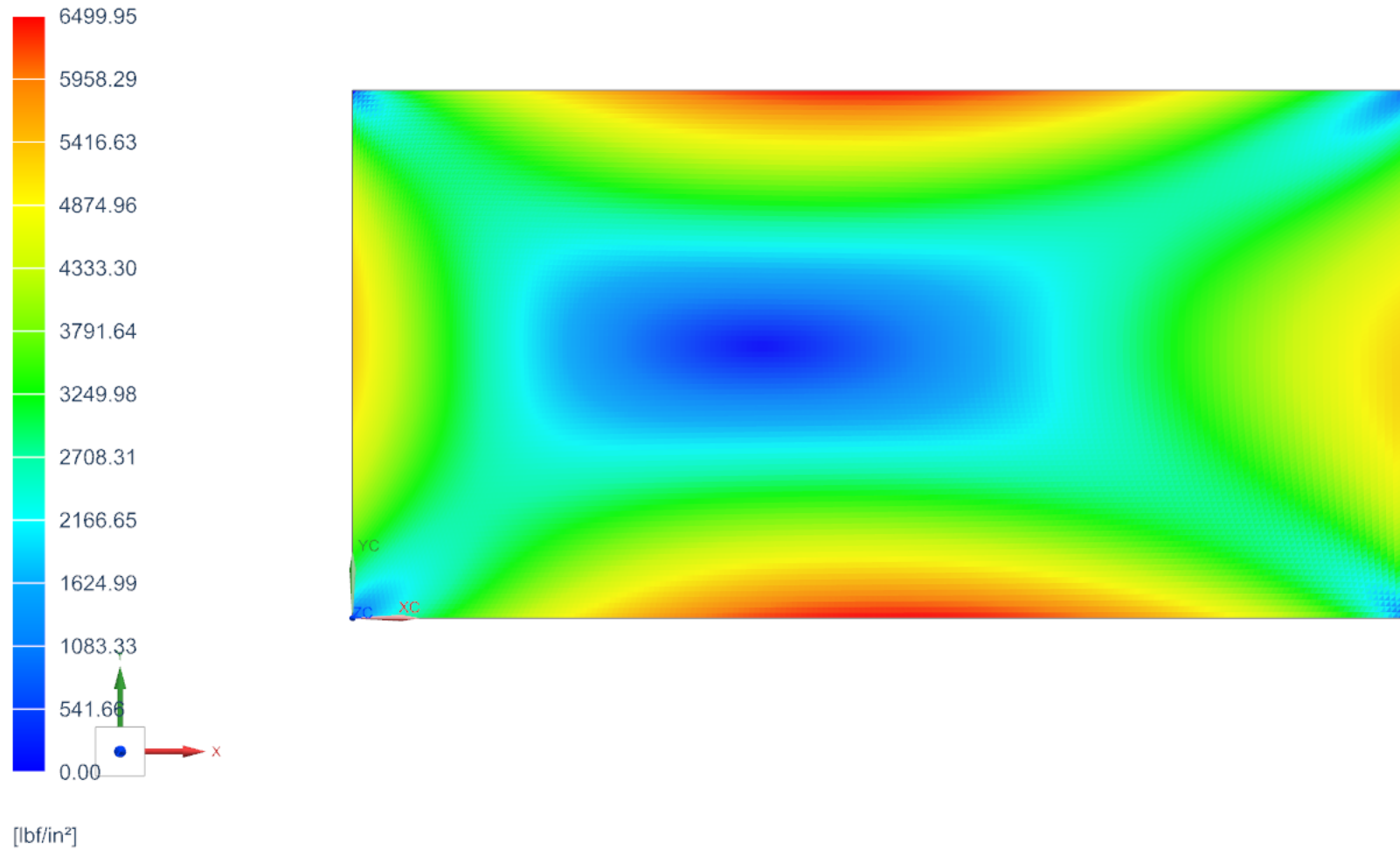Ply orientation: [0, 30, -30, 45, -45, 30, -30, 45, -45, 90, 90]S
Mass: 88g
Min FoS: 2.000

Explanation:
Note that I believe that my Hashin and Poly safety criteria are incorrectly implemented from last assignment, and the FoS's presented are abnormally low. I am only going off of max stress for this assignment, which I understand is likely incorrect.

To design my laminate, I used Siemens NX Pre/Post FEA to apply the loads to an arbitrary material just to get the loadpaths. Here is the result from Load 1:

E25_PRT_DESIGN6_LAMINATE_A1_sim1 : Solution 2 Result
Subcase - Statics 1, Static Step 1
Stress - Element-Nodal, Unaveraged, Von-Mises
Shell Section : Top
Min : 0.00, Max : 6499.95, Units = lbf/in²
Deformation : Displacement - Nodal Magnitude

6499.95

5958.29

5416.63

4874.96

4333.30

3791.64

3249.98

2708.31

2166.65

1624.99

1083.33

541.66

0.00

[lbf/in²]

I measured two main load direction: ~30deg and ~45 deg. So, I decided to make an angle ply laminate containing -30, 30, -45-, 45-, 0- and 90-degree ply orientations. I tried to distribute these uniformally through the laminate, and also used some trial and error (for ply count and direction distribution) until my minimum FoS was 2 or greater.

This yields a mass of 88g, and FoS of 2.000 for Load 1 and 2.098 for Load 2.