MECH530 – Assignment 4
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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) = [0.000; 0.000; 0.000]

M_vector (Nm) = [-2450.000; 0.000; 0.000]

epsilon_o_vector = [
  0.000e+00
  0.000e+00
  0.000e+00
]

k_vector (m^-1) = [
  -3.960e-01
  8.923e-02
  1.099e-02
]

```
================ 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      -0.0022773       {'[-2.277e-03, 5.131e-04, 6.317e-05]' }    {'[-2.277e-03, 5.131e-04, 6.317e-05]' }    {'[-4.125e+02, -1.289e+00, 4.529e-01]' }
   1        0          0.005625      Bottom   -0.0022278       {'[-2.228e-03, 5.019e-04, 6.180e-05]' }    {'[-2.228e-03, 5.019e-04, 6.180e-05]' }    {'[-4.036e+02, -1.261e+00, 4.431e-01]' }
   2        0          0.005625      Top      -0.0022278       {'[-2.228e-03, 5.019e-04, 6.180e-05]' }    {'[-2.228e-03, 5.019e-04, 6.180e-05]' }    {'[-4.036e+02, -1.261e+00, 4.431e-01]' }
   2        0          0.0055        Bottom   -0.0021782       {'[-2.178e-03, 4.908e-04, 6.042e-05]' }    {'[-2.178e-03, 4.908e-04, 6.042e-05]' }    {'[-3.946e+02, -1.233e+00, 4.332e-01]' }
   3       20          0.0055        Top      -0.0018466       {'[-2.178e-03, 4.908e-04, 6.042e-05]' }    {'[-1.847e-03, 1.591e-04, 1.762e-03]' }    {'[-3.353e+02, -3.703e+00, 1.263e+01]' }
   3       20          0.005375      Bottom   -0.0018046       {'[-2.129e-03, 4.796e-04, 5.905e-05]' }    {'[-1.805e-03, 1.555e-04, 1.722e-03]' }    {'[-3.277e+02, -3.619e+00, 1.235e+01]' }
   4      -20          0.005375      Top      -0.0018426       {'[-2.129e-03, 4.796e-04, 5.905e-05]' }    {'[-1.843e-03, 1.935e-04, -1.631e-03]'}    {'[-3.344e+02, -3.336e+00, -1.170e+01]'}
   4      -20          0.00525       Bottom   -0.0017997       {'[-2.079e-03, 4.685e-04, 5.768e-05]' }    {'[-1.800e-03, 1.890e-04, -1.593e-03]'}    {'[-3.267e+02, -3.259e+00, -1.143e+01]'}
   5        0          0.00525       Top      -0.0020792       {'[-2.079e-03, 4.685e-04, 5.768e-05]' }    {'[-2.079e-03, 4.685e-04, 5.768e-05]' }    {'[-3.767e+02, -1.177e+00, 4.135e-01]' }
   5        0          0.005125      Bottom   -0.0020297       {'[-2.030e-03, 4.573e-04, 5.630e-05]' }    {'[-2.030e-03, 4.573e-04, 5.630e-05]' }    {'[-3.677e+02, -1.149e+00, 4.037e-01]' }
   6       90          0.005125      Top       0.00045731      {'[-2.030e-03, 4.573e-04, 5.630e-05]' }    {'[4.573e-04, -2.030e-03, -5.630e-05]'}    {'[7.726e+01, -1.968e+01, -4.037e-01]' }
   6       90          0.005         Bottom    0.00044616      {'[-1.980e-03, 4.462e-04, 5.493e-05]' }    {'[4.462e-04, -1.980e-03, -5.493e-05]'}    {'[7.538e+01, -1.920e+01, -3.939e-01]' }
   7       90         -0.005         Top      -0.00044616      {'[1.980e-03, -4.462e-04, -5.493e-05]'}    {'[-4.462e-04, 1.980e-03, 5.493e-05]' }    {'[-7.538e+01, 1.920e+01, 3.939e-01]' }
   7       90         -0.005125      Bottom   -0.00045731      {'[2.030e-03, -4.573e-04, -5.630e-05]'}    {'[-4.573e-04, 2.030e-03, 5.630e-05]' }    {'[-7.726e+01, 1.968e+01, 4.037e-01]' }
   8        0         -0.005125      Top       0.0020297       {'[2.030e-03, -4.573e-04, -5.630e-05]'}    {'[2.030e-03, -4.573e-04, -5.630e-05]'}    {'[3.677e+02, 1.149e+00, -4.037e-01]' }
   8        0         -0.00525       Bottom    0.0020792       {'[2.079e-03, -4.685e-04, -5.768e-05]'}    {'[2.079e-03, -4.685e-04, -5.768e-05]'}    {'[3.767e+02, 1.177e+00, -4.135e-01]' }
   9      -20         -0.00525       Top       0.0017997       {'[2.079e-03, -4.685e-04, -5.768e-05]'}    {'[1.800e-03, -1.890e-04, 1.593e-03]' }    {'[3.267e+02, 3.259e+00, 1.143e+01]'   }
   9      -20         -0.005375      Bottom    0.0018426       {'[2.129e-03, -4.796e-04, -5.905e-05]'}    {'[1.843e-03, -1.935e-04, 1.631e-03]' }    {'[3.344e+02, 3.336e+00, 1.170e+01]'   }
  10       20         -0.005375      Top       0.0018046       {'[2.129e-03, -4.796e-04, -5.905e-05]'}    {'[1.805e-03, -1.555e-04, -1.722e-03]'}    {'[3.277e+02, 3.619e+00, -1.235e+01]'  }
  10       20         -0.0055        Bottom    0.0018466       {'[2.178e-03, -4.908e-04, -6.042e-05]'}    {'[1.847e-03, -1.591e-04, -1.762e-03]'}    {'[3.353e+02, 3.703e+00, -1.263e+01]'  }
  11        0         -0.0055        Top       0.0021782       {'[2.178e-03, -4.908e-04, -6.042e-05]'}    {'[2.178e-03, -4.908e-04, -6.042e-05]'}    {'[3.946e+02, 1.233e+00, -4.332e-01]'  }
  11        0         -0.005625      Bottom    0.0022278       {'[2.228e-03, -5.019e-04, -6.180e-05]'}    {'[2.228e-03, -5.019e-04, -6.180e-05]'}    {'[4.036e+02, 1.261e+00, -4.431e-01]'  }
  12        0         -0.005625      Top       0.0022278       {'[2.228e-03, -5.019e-04, -6.180e-05]'}    {'[2.228e-03, -5.019e-04, -6.180e-05]'}    {'[4.036e+02, 1.261e+00, -4.431e-01]'  }
  12        0         -0.00575       Bottom    0.0022773       {'[2.277e-03, -5.131e-04, -6.317e-05]'}    {'[2.277e-03, -5.131e-04, -6.317e-05]'}    {'[4.125e+02, 1.289e+00, -4.529e-01]'  }
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================= SKATEBOARD RESULTS =================

P = -1960.00 N
L = 0.50 m
b = 0.10 m
M_1 = (P * L) / (4 * b) = -2450.00 Nm
d_11 = 1.617e-04 Nm^-1
delta_midpoint = ((P * L^3) / (48 * b)) * d_11 = -0.82509 cm

The highest magnitude of epsilon_x is 0.002277 at Ply 12 Bottom – FAIL! (magnitude > 0.002)

The midpoint deflection (delta_midpoint) is -0.82509 cm – FAIL! (magnitude > 0.5 cm)
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