MEK4540 ASSIGNMENT 1 AUTUMN 2011 – NUMERICAL SOLUTIONS

All values shown here were obtained using Matlab. Some small deviations must be expected if the elastic ply properties are first calculated by hand and then input to Matlab.

The units are consistently newtons and millimetres (and MPa), except for the density in part a).

PART a)

Wf = 0.7467
Wm = 0.2533
rhoc = 1.9074 (g/cm^3)
Vf = 0.5607
Vm = 0.4393
t = 0.1053

PART b)

EL = 4.2089e+004
ETsimple = 7.3021e+003
Halpin-Tsai: ET = 1.3141e+004
vLT = 0.2659

Gf = 3.0167e+004
Gm = 1.2593e+003
GLTsimple = 2.7216e+003
Halpin-Tsai: GLT = 3.9419e+003

PART c)

```
Q =
  1.0e+004 *
    4.3039    0.3573         0
    0.3573    1.3438         0
         0         0    0.3942

angle = 0
Qk =
  1.0e+004 *
    4.3039    0.3573         0
    0.3573    1.3438         0
         0         0    0.3942

angle = 90
Qk =
  1.0e+004 *
    1.3438    0.3573   -0.0000
    0.3573    4.3039    0.0000
   -0.0000    0.0000    0.3942

angle = 45
Qk =
  1.0e+004 *
    1.9848    1.1964    0.7400
    1.1964    1.9848    0.7400
    0.7400    0.7400    1.2333
```

angle = -45
Qk =
1.0e+004 *

1.9848	1.1964	-0.7400
1.1964	1.9848	-0.7400
-0.7400	-0.7400	1.2333

PART d)

Lay-up (i)

A1 =
1.0e+004 *

2.6493	0.6546	0.0000
0.6546	1.4023	0.0000
0.0000	0.0000	0.6856

B1 =
1.0e-012 *

-0.2274	-0.0284	0
-0.0284	-0.2274	0
0	0	0.0284

D1 =
1.0e+003 *

1.6757	0.3480	0.0692
0.3480	0.7996	0.0692
0.0692	0.0692	0.3664

Qtot1 =
1.0e+004 *

2.6493	0.6546	0.0000	-0.0000	-0.0000	0
0.6546	1.4023	0.0000	-0.0000	-0.0000	0
0.0000	0.0000	0.6856	0	0	0.0000
-0.0000	-0.0000	0	0.1676	0.0348	0.0069
-0.0000	-0.0000	0	0.0348	0.0800	0.0069
0	0	0.0000	0.0069	0.0069	0.0366

Lay-up (ii)

A2 =
1.0e+004 *

2.0258	0.6546	-0.0000
0.6546	2.0258	0.0000
-0.0000	0.0000	0.6856

B2 =
1.0e-012 *

-0.2274	-0.0284	0
-0.0284	-0.2274	0
0	0	0.0284

D2 =
1.0e+003 *

1.6527	0.3480	0.0692
0.3480	0.8227	0.0692
0.0692	0.0692	0.3664

Qtot2 =

1.0e+004 *

2.0258	0.6546	-0.0000	-0.0000	-0.0000	0
0.6546	2.0258	0.0000	-0.0000	-0.0000	0
-0.0000	0.0000	0.6856	0	0	0.0000
-0.0000	-0.0000	0	0.1653	0.0348	0.0069
-0.0000	-0.0000	0	0.0348	0.0823	0.0069
0	0	0.0000	0.0069	0.0069	0.0366

<u>Lay-up (iii)</u>

A3 =

1.0e+004 *

1.3247	0.3273	0.0000
0.3273	0.7011	0.0000
0.0000	0.0000	0.3428

B3 =

0	0.0000	-82.0889
0.0000	0	-82.0886
-82.0889	-82.0886	0.0000

D3 =

250.1089	28.7986	0
28.7986	88.7226	0
0	0	31.0967

Qtot3 =

1.0e+004 *

1.3247	0.3273	0	0	0.0000	-0.0082
0.3273	0.7011	0	0.0000	0	-0.0082
0	0	0.3428	-0.0082	-0.0082	0.0000
0	0.0000	-0.0082	0.0250	0.0029	0
0.0000	0	-0.0082	0.0029	0.0089	0
-0.0082	-0.0082	0.0000	0	0	0.0031

PART e)

Here we have used just the A matrices since B = 0 and there is no bend-stretch coupling. We could instead have used the full 6x6 stiffness matrices with the bending moments in the N-vector set to zero.

<u>Lay-up (i)</u>

A1inv =

1.0e-003 *

0.0427	-0.0199	-0.0000
-0.0199	0.0806	-0.0000
-0.0000	-0.0000	0.1459

Strain vector for applied Nx = 1 (MPa) x 8t (mm)

EpsilonFx1 =

1.0e-004 *

0.3595

-0.1678

-0.0000

Strain vector for applied Ny = 1 (MPa) x 8t (mm)
EpsilonFy1 =
1.0e-004 *
-0.1678
0.6792
-0.0000

Strain vector for applied Nxy = 1 (MPa) x 8t (mm)
EpsilonFxy1 =
1.0e-003 *
-0.0000
-0.0000
0.1229

Resulting moduli:
Ex1 = 2.7817e+004 (MPa)
nuxy1 = 0.4668
Ey1 = 1.4724e+004 (MPa)
nuyx1 = 0.2471
Gxy1 = 8.1373e+003 (MPa)

Lay-up (ii)

A2inv =
1.0e-003 *
0.0551 -0.0178 0.0000
-0.0178 0.0551 -0.0000
0.0000 -0.0000 0.1459

Mid-plane strain and curvature vector for applied Nx = 1 (MPa) x 8t (mm)
EpsilonFx2 =
0.0464
-0.0150
0.0000

Mid-plane strain and curvature vector for applied Ny = 1 (MPa) x 8t (mm)
EpsilonFy2 =
-0.0150
0.0464
-0.0000

Mid-plane strain and curvature vector for applied Nxy = 1 (MPa) x 8t (mm)
EpsilonFxy2 =
0.0000
-0.0000
0.1229

Resulting elastic properties:
Ex2 = 21 533 (MPa)
nuxy2 = 0.3231
Ey2 = 21 533 (MPa)
nuyx2 = 0.3231
Gxy2 = 8 137 (MPa)

NB: This lay-up is quasi-isotropic!

PART f)

Ply strength properties (given)
s1t = 490 (MPa)
s1c = 463 (MPa)
s2t = 170 (MPa)
s2c = 175 (MPa)
s12 = 189 (MPa)
F12star = -0.5000

F12 = -6.0861e-006

Applied stresses (given)
sigmax = 300 (MPa)
sigmay = 140 (MPa)
tauxy = 65 (MPa)

Total thickness T = 0.8426

Convert stresses to N-vector:
N =
252.7712 (N/mm)
117.9599 (N/mm)
54.7671 (N/mm)

Resulting mid-plane strains
epsilon =
0.0084
0.0045
0.0080

Stresses in first 2 plies in x,y co-ordinates. Ply 1 in 1st column, ply 2 in 2nd column
sigma =
379.0424 280.0705 (MPa)
90.2693 248.8434 (MPa)
31.4873 194.0506 (MPa)

Stresses in first 2 plies transformed to L,T co-ordinates
sigmaply =
379.0424 458.5076 (MPa)
90.2693 70.4063 (MPa)
31.4873 -15.6133 (MPa)

Application of Tsai-Wu criterion to first 2 plies:
F_{TW} =
0.4885 0.6644
Positive roots only of equation for R:
Rfactor =
1.4180 1.2198
invRfactor =
0.7052 0.8198

Both plies are OK!

BH 19.10.2011