Stress Analyses of Modular Coils and Coil structure
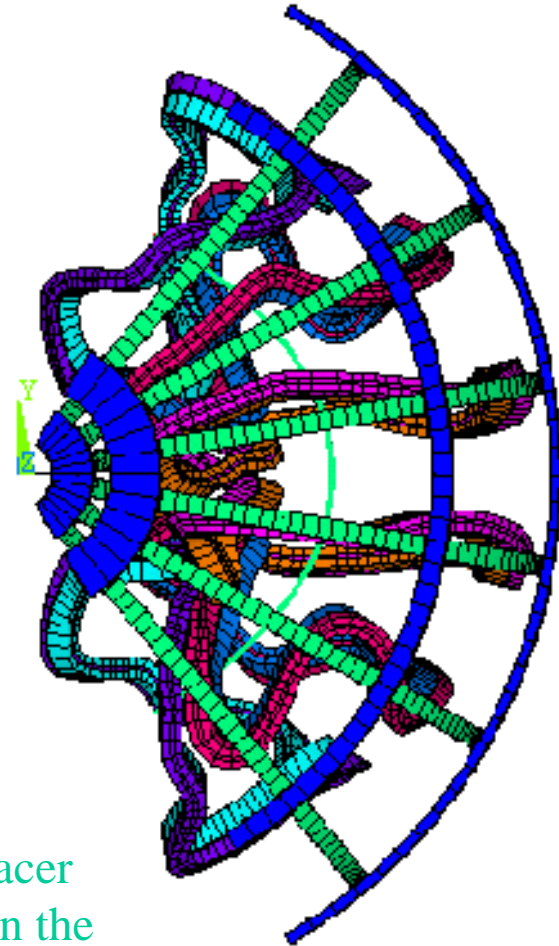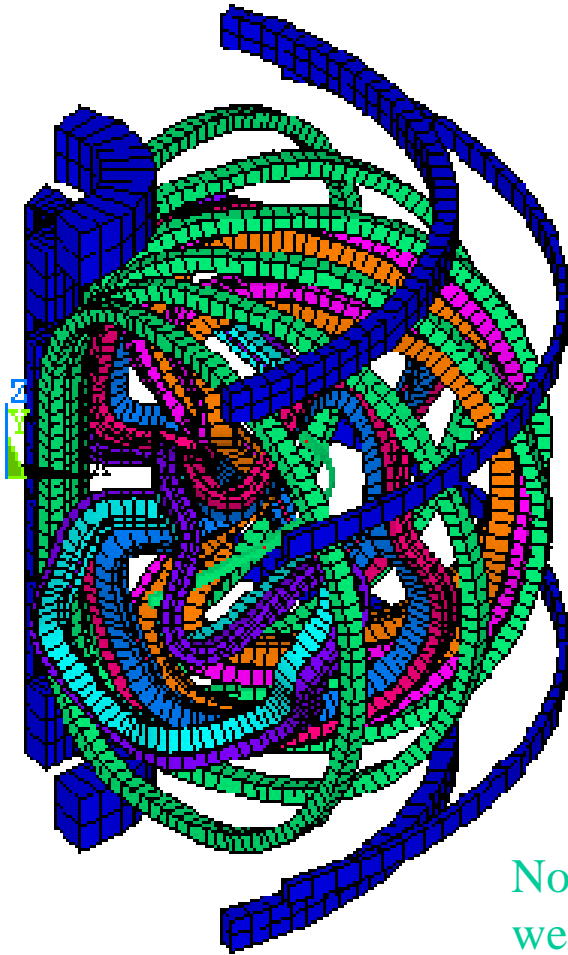
Part 1 – EM Analysis

H.M. Fan
PPPL
April 2, 2002

# ANSYS Model for Winding Pack and Tee

Note: Tee and spacer were unselected in the EM analysis

Currents, Materials, and Element Type Numbers

- Currents are selected from 2T high beta scenario at 0.0 seconds

| Coil	Part	Current (A/turn)	Turn	Material Number	Elem. Type Number
M1	Coil	22228	36	1	3
	Tee	–	–	2	3
	Spacer	–	–	3	3
M2	Coil	22998	36	4	2
	Tee	–	–	5	2
	Spacer	–	–	6	2
M3	Coil	17518	36	7	1
	Tee	–	–	8	1
	Spacer	–	–	9	1
PF1		16703	56	10	4
PF2		16703	68	10	5
PF3		5356	112	10	6
PF4		4967	100	10	7
PF5		–5625	24	10	8
PF6		740	8	10	9
TF		2071	12	11	10
	Plasma	0	1	11	11

Magnetic Flux Density of PF and TF Coils
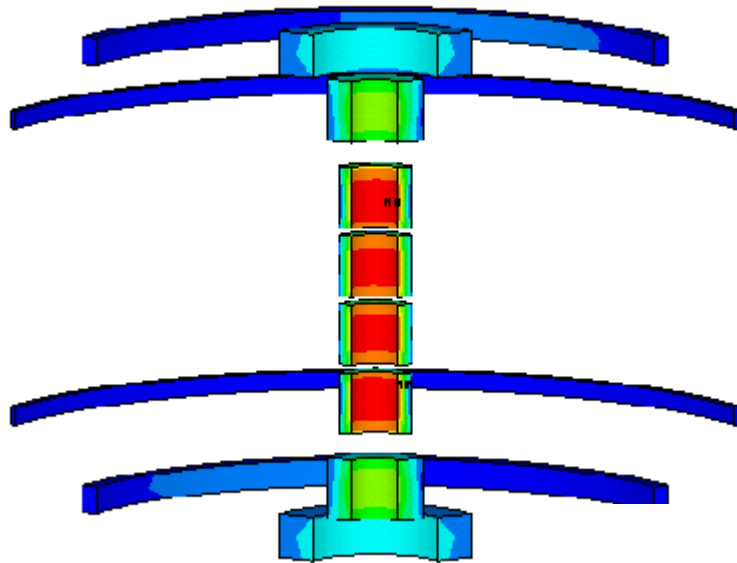
NODAL SOLUTION
STEP=2
SUB =1
TIME=2
BSUM   (AVG)
RSYS=0
PowerGraphics
EFACET=1
AVRES=Mat
SMN =.035369
SMX =2.763

.035369
.338479
.641589
.944699
1.248
1.551
1.854
2.157
2.46
2.763

Flux density
unit in Tesla
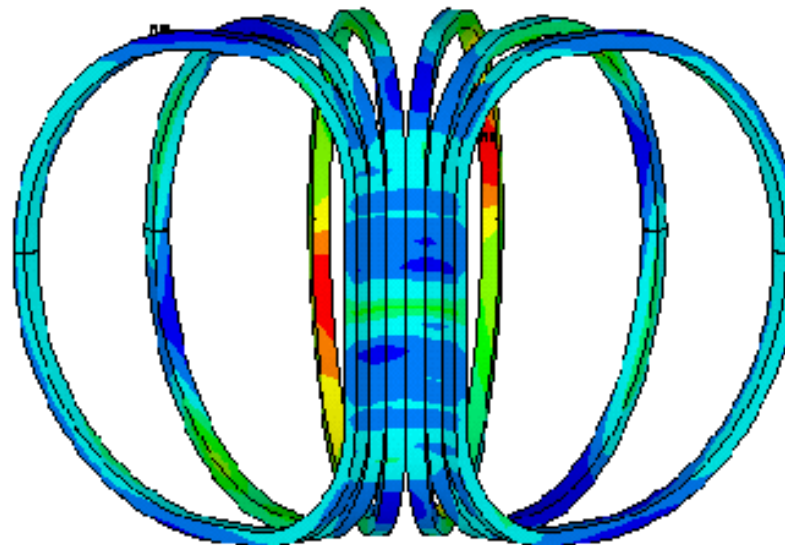
NODAL SOLUTION
STEP=2
SUB =1
TIME=2
BSUM   (AVG)
RSYS=0
PowerGraphics
EFACET=1
AVRES=Mat
SMN =.023035
SMX =.856147

.023035
.115603
.208171
.300739
.393307
.485875
.578443
.671011
.763579
.856147

Magnetic Flux Density of Modular Coils

```
NODAL SOLUTION
STEP=2
SUB =1
TIME=2
BSUM        (AVG)
RSYS=0
PowerGraphics
EFACET=1
AVRES=Mat
SMN =.137947
SMX =4.473
```

```
     .137947
     .619646
    1.101
    1.583
    2.065
    2.546
    3.028
    3.51
    3.992
    4.473
```
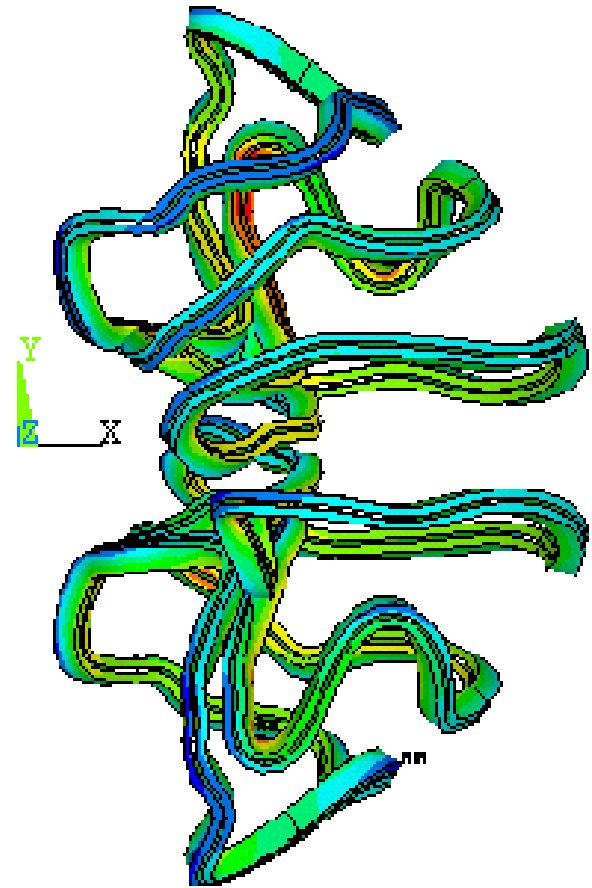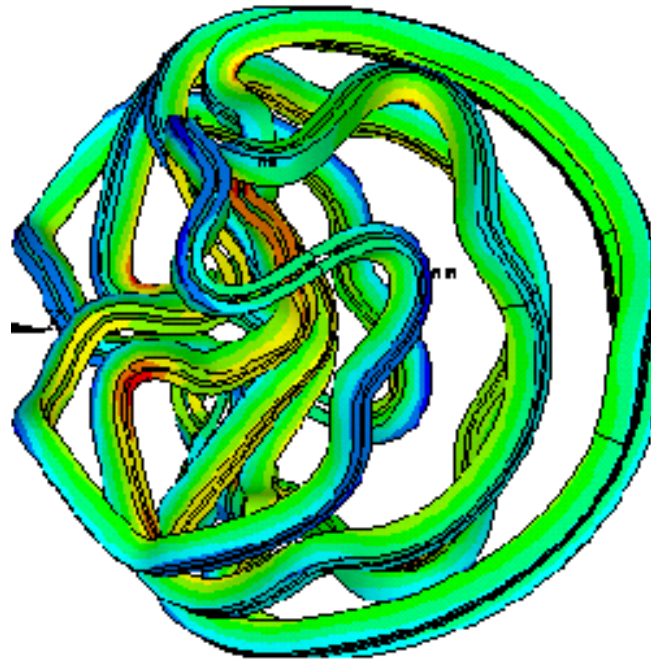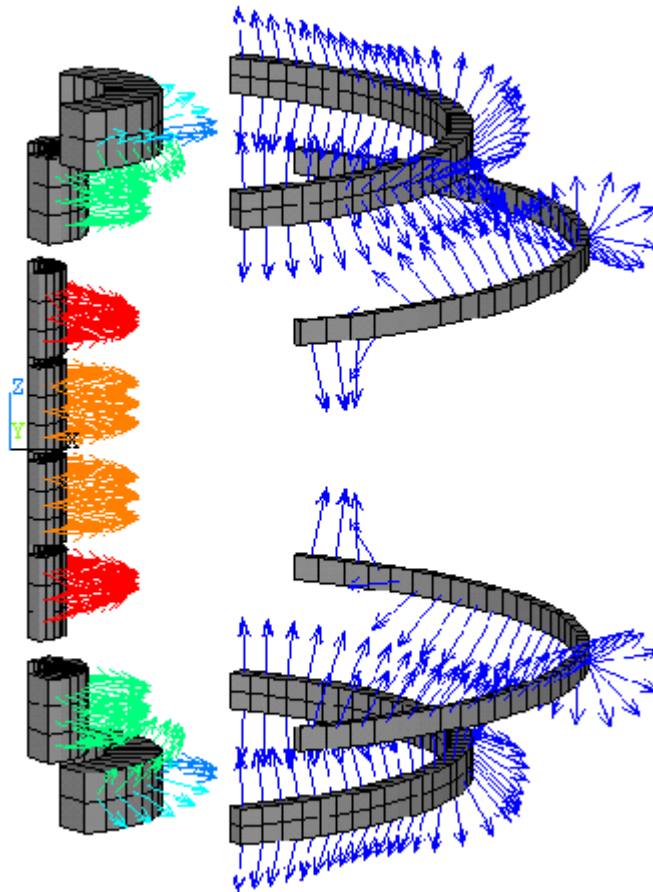
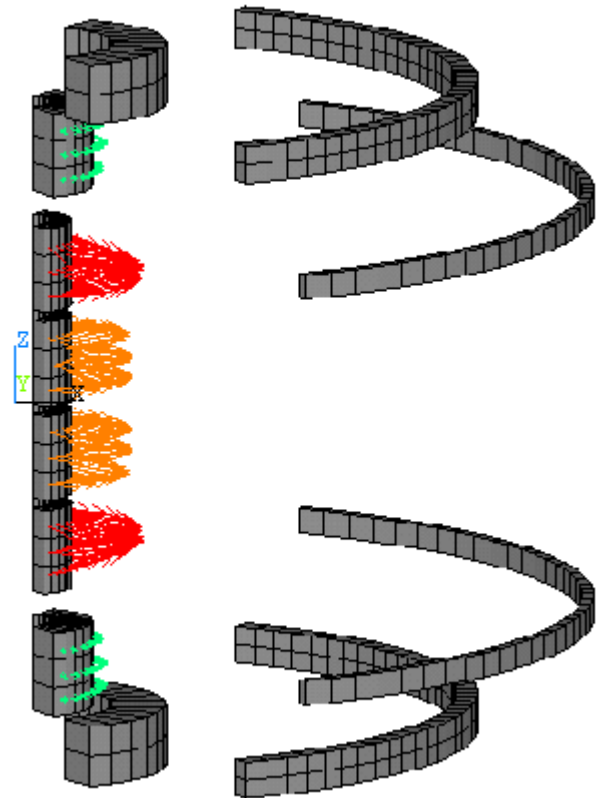Flux density
unit in Tesla

Element Magnetic Forces of PF Coils

VECTOR
STEP=2
SUB =1
TIME=2
FMAG
ELEM=6533
MIN=15.106
MAX=19666

15.106
2199
4382
6566
8749
10933
13116
15300
17483
19666

Magnetic force
unit in Newton

Uniform vector plot

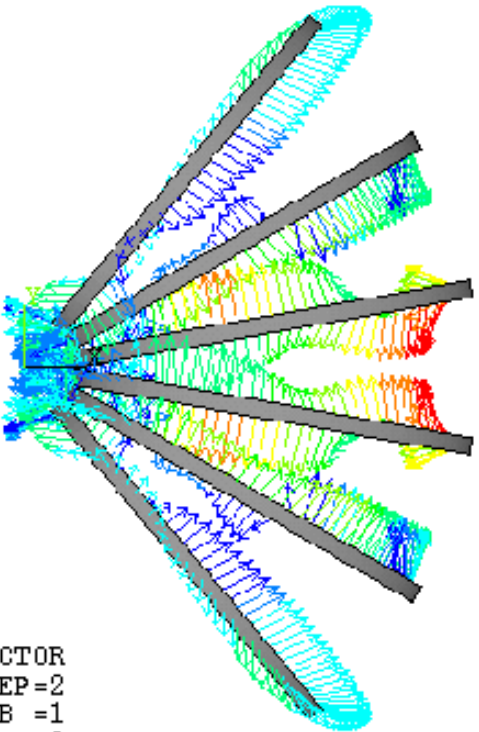Magnitude based vector plot

Element Magnetic Forces of TF Coils
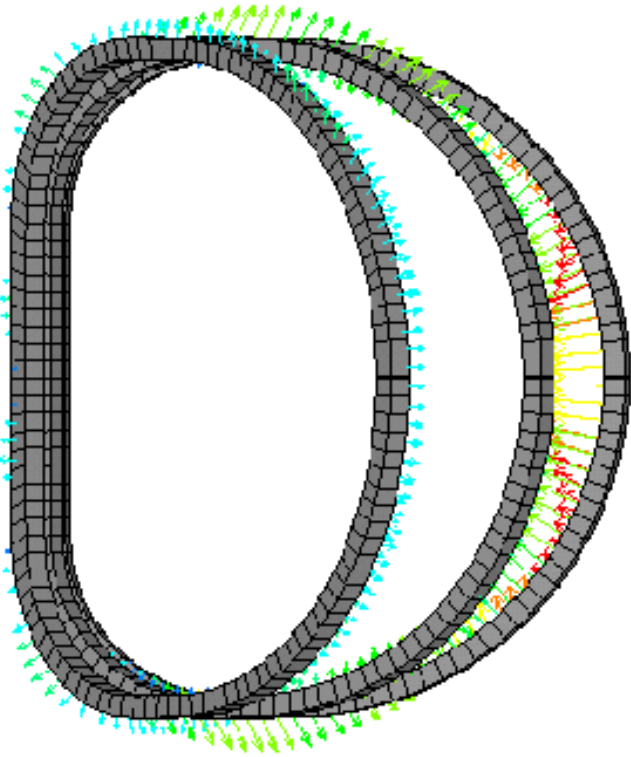
Magnitude based vector plot
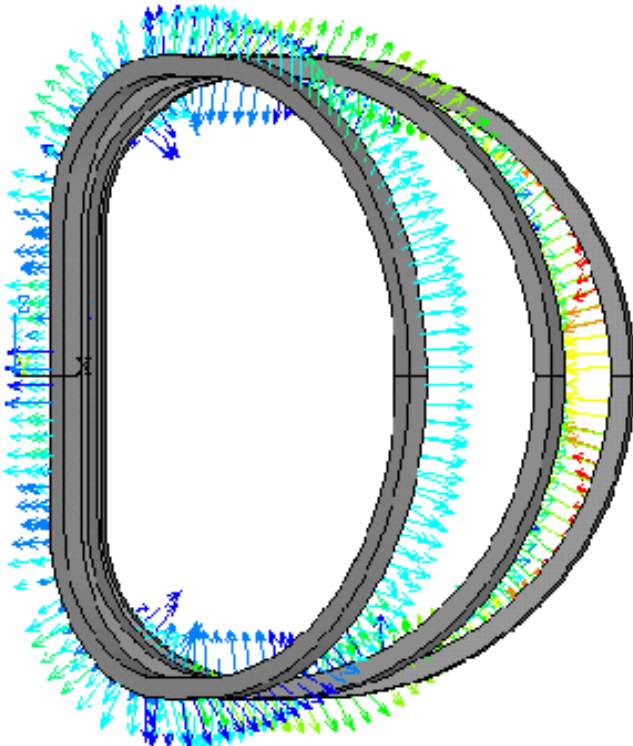
Uniform vector plot

Uniform vector plot

```
VECTOR
STEP=2
SUB =1
TIME=2
FMAG
ELEM=6992
MIN=34.458
MAX=1020
      34.458
      144.004
      253.551
      363.097
      472.644
      582.19
      691.737
      801.283
      910.83
      1020
```
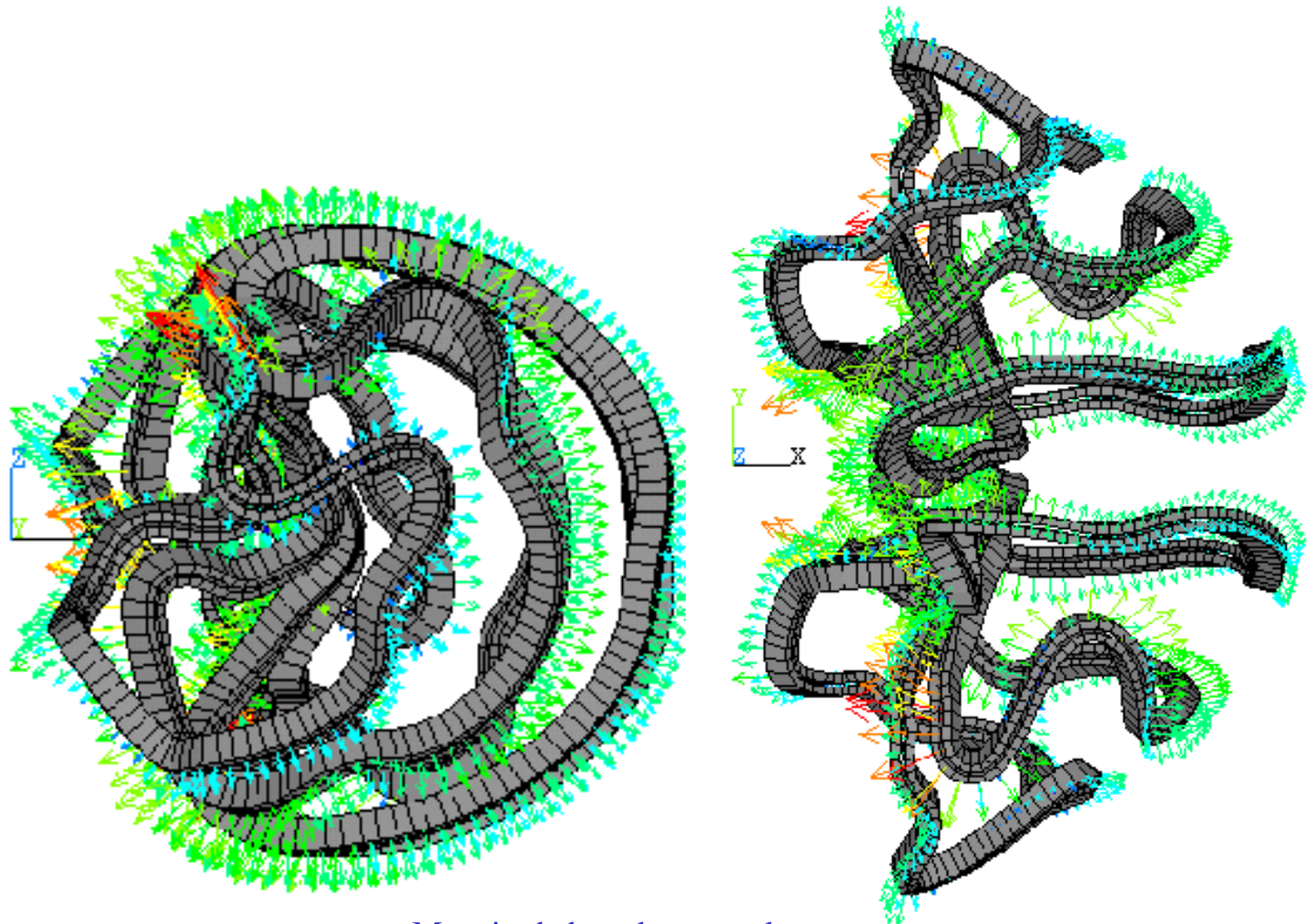
Magnetic force
unit in Newton

Element Magnetic Forces of Modular Coils

VECTOR
STEP=2
SUB =1
TIME=2
FMAG
ELEM=3961
MIN=1229
MAX=62439

1229
8030
14831
21633
28434
35235
42036
48837
55638
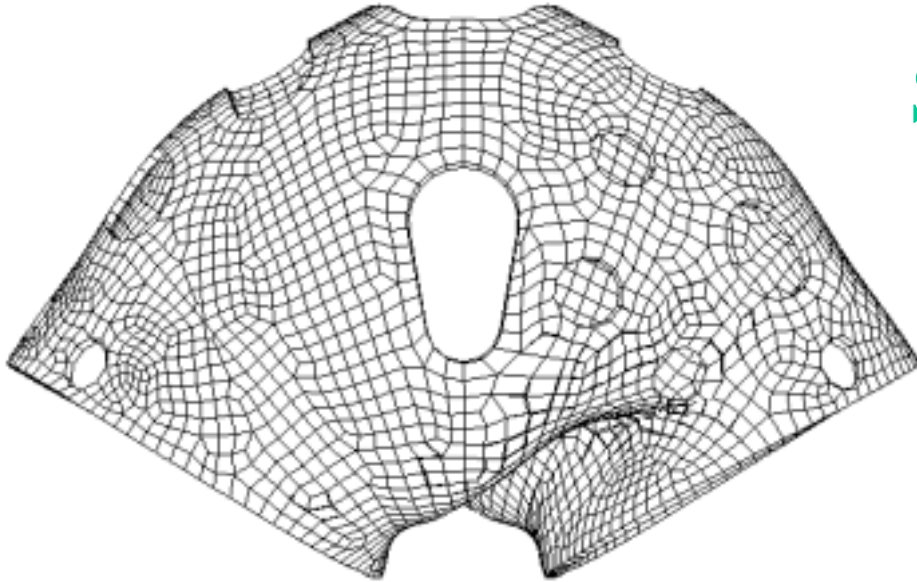62439

Magnetic force
unit in Newton

Magnitude based vector plot
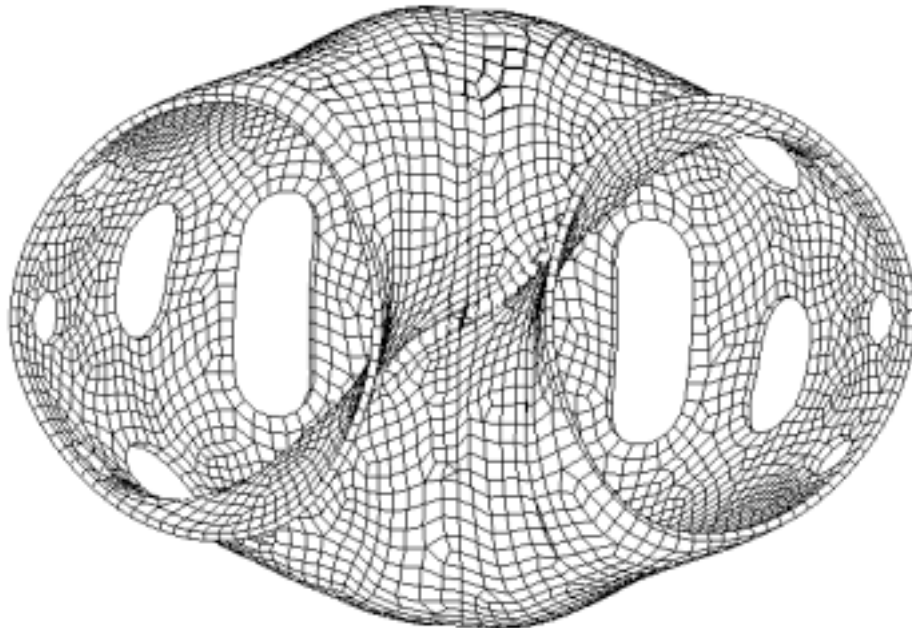
Structural Shell Model

Developed by offsetting "paver" mesh of shell inner surface

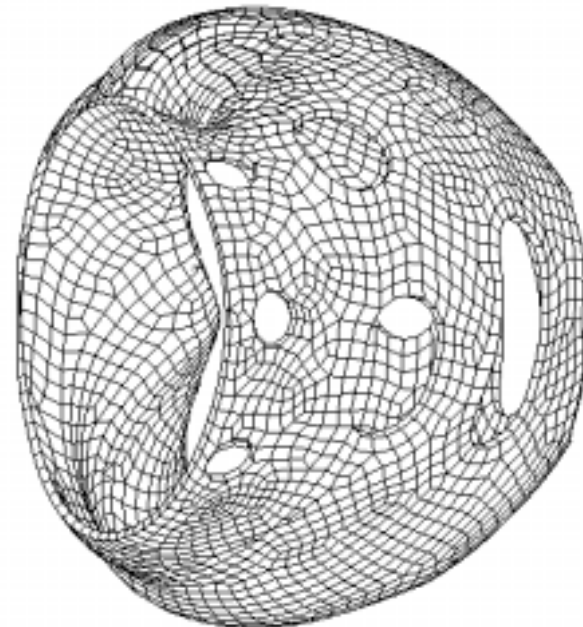Equivalencing of outer surface nodes not complete (cracks visible)

Need to adjust offset nodes to radial planes and add wings for cyclic sym

Structural Shell Model

Spacer
E=500-MPa

Tee / Shell
E=200E3-MPa

Cyclic Sym
boundary

Constraint Eq
between tee
nodes and shell
elems

Coil
E=0.6(100E3)+0.4(500)
E=60.2E3-MPa