

## Apéndice A

# PROGRAMACIÓN ANSYS

A continuación vamos a mostrar los códigos que introducimos en ANSYS para obtener la solución de los distintos problemas. Notar que no se van a mostrar todos los códigos de todos los problemas para cada metodología y tipos de mallas distintas, sino uno característico para cada ejemplo. Las diferencias entre los distintos códigos de cada problema estarán en la declaración de elementos, keyoptions, constantes reales, modelado y en la forma a través de la cuál obtenemos los elementos de contacto.

### CILINDROS 2-D

#### SUPERFICIE-A-SUPERFICIE Y MALLAS COINCIDENTES

```
/PREP7 SMRT,OFF
ANTYPE,STATIC
ET,1,PLANE42
ET,2,TARGE169
ET,3,CONTA172
KEYOPT,3,5,1
KEYOPT,3,2,0
!!modelado y mallado!!
MP,EX,1,30000
MP,NUXY,1,0.25
MP,EX,2,29120
MP,NUXY,2,0.30
MP,MU,3,0.1
K,1
K,2,13
K,3,13,84
K,4,13,90
K,5,11,90
L,1,5
L,2,3
LESIZE,ALL,,9
L,3,4
LOCAL,11,1,,13
L,3,5
CSYS,1
A,1,2,3,5
A,5,3,4,4
MAT,2
```

```

MSHK,1
MSHA,0,2D
ESIZE,,26
AMESH,1,2
LOCAL,12,1,,26,-90
K,11
K,12,13
K,13,13,6
K,14,13,90
K,15,11
L,11,15
L,13,14
LESIZE,7,,9
LESIZE,8,,9
L,12,13
CSYS,11
L,13,15
CSYS,12
MAT,1
A,12,13,15,15
A,15,13,14,11
ESIZE,,26
AMESH,3,4
!!elementos de contacto!!
LSEL,S,LINE,,9
NSLL,,1
CM,CYL1,NODE
REAL,1
TYPE,3
ESURF
LSEL,S,LINE,,3
NSLL,,1
REAL,1
TYPE,2
ESURF
NSEL,ALL
!!condiciones de contorno!!
CSYS,0
NSEL,S,LOC,Y,26
CP,1,UY,ALL
*GET,NC,NODE,,NUM,MIN
NSEL,S,LOC,X D,ALL,UX
NSEL,S,LOC,Y
D,ALL,UY
NSEL,ALL
FINISH
!!fin del preprocesador!!
/SOLU
F,NC,FY,-800
NSUBST,1,10,1
SOLCONTROL,ON
SOLVE
FINISH
    
```

## CILINDROS 3-D

### NODO-A-NODO Y MALLAS COINCIDENTES

```

/PREP7 $SMRT,OFF
ANTYPE,STATIC
!!tipos de elementos y propiedades!!
ET,1,SOLID45
ET,2,CONTA178
KEYOPT,2,2,1
KEYOPT,2,5,2
R,1,3e4,,,,,0.001,,
MP,EX,1,30000
MP,NUXY,1,0.25
MP,EX,2,29120
MP,NUXY,2,0.30
MP,MU,3,0.1
!!modelado y mallado!!
CSYS,1
K,1
K,2,13
K,3,13,84
K,4,13,90
K,5,11,90
KGEN,2,1,5,1,,1,100
L,1,5
L,2,3
L,101,105
L,102,103
LESIZE,ALL,,8
L,1,101
*REPEAT,5,1,1
LESIZE,5,,5
*REPEAT,5,1
LOCAL,11,1,,13
L,3,5
L,103,105
CSYS,1
MAT,2
MSHK,1
MSHA,0,3D
ESIZE,,12
    
```

V,1,2,3,5,101,102,103,105	E,876,1538
V,5,3,4,4,105,103,104,104	E,821,1534
VMESH,ALL	E,186,1517
LOCAL,12,1,,26,-90	E,835,1577
K,11	E,839,1573
K,12,13	E,843,1569
K,13,13,6	E,847,1565
K,14,13,90	E,851,1561
K,15,11	E,855,1557
KGEN,2,11,15,1,,1,100	E,859,1553
L,11,15	E,863,1549
L,13,14	E,867,1545
LESIZE,18,,8	E,871,1541
LESIZE,19,,8	E,875,1537
L,11,111	E,820,1533
*REPEAT,5,1,1	E,185,1516
LESIZE,20,,5	E,834,1576
*REPEAT,5,1	E,838,1572
CSYS,11	E,842,1568
L,13,15	E,846,1564
L,113,115	E,850,1560
CSYS,12	E,854,1556
MAT,1	E,858,1552
ESIZE,,12	E,862,1548
V,12,13,15,15,112,113,115,115	E,866,1544
V,15,13,14,11,115,113,114,111	E,870,1540
VMESH,3,4	E,874,1536
!elementos de contacto!!	E,819,1532
TYPE,2	E,184,1515
REAL,1	E,833,1575
MAT,3	E,837,1571
E,183,1514	E,841,1567
E,822,1520	E,845,1563
E,823,1521	E,849,1559
E,824,1522	E,853,1555
E,825,1523	E,857,1551
E,826,1524	E,861,1547
E,827,1525	E,865,1543
E,828,1526	E,869,1539
E,829,1527	E,873,1535
E,830,1528	E,818,1531
E,831,1529	E,14,1388
E,832,1530	E,704,1399
E,817,1519	E,705,1398
E,187,1518	E,706,1397
E,836,1578	E,707,1396
E,840,1574	E,708,1395
E,844,1570	E,709,1394
E,848,1566	E,710,1393
E,852,1562	E,711,1392
E,856,1558	E,712,1391
E,860,1554	E,713,1390
E,864,1550	E,714,1389
E,868,1546	E,703,1387
E,872,1542	!!condiciones de contorno!!

```

CSYS,0
NSEL,S,LOC,Y,26
CP,1,UY,ALL
*GET,NC,NODE,,NUM,MIN
NSEL,S,LOC,X
D,ALL,UX
NSEL,S,LOC,Y
D,ALL,UY
NSEL,S,LOC,Z
D,ALL,UZ
NSEL,S,LOC,Z,1

D,ALL,UZ
NSEL,ALL
FINISH
!!fin del pre-procesador!!
/SOLU
F,NC,FY,-1200
AUTOTS,ON,ON
NSUBST,1,10,1
SOLVE
FINISH
    
```

## ESFERA-PLANO

### NODO-A-SUPERFICIE Y MALLAS NO COINCIDENTES TIPO 2

```

/PREP7
!!tipos de elementos y propiedades!!
ET,1,SOLID45
ET,2,TARGE170
ET,3,CONTA175
keyopt,3,3,1
keyopt,3,5,1
MP,EX,1,0.1e5
MP,NUXY,1,0.30
MP,EX,2,0.1e9
MP,NUXY,2,0.30
MP,MU,3,0
!!modelado y mallado!!
wplane,1,0,0,0,1,0,0,0,1
sphere,50,0,0,-180
wplane,1,-50,0,-50,50,0,-50,-50,0,0
vsbw,all
vdele,3
wplane,1,0,-50,0,50,-50,0,0,50,0
wplane,1,-50,50,-1.3,50,50,-1.3,-50,0,-1.3
vsbw,2
wplane,1,-1.3,50,-1.3,-1.3,50,0,-1.3,0,-1.3
vsbw,3
wplane,1,1.3,50,-1.3,1.3,50,0,1.3,0,-1.3
vsbw,4
wplane,1,-1.3,0,-1.3,-35.35534,0,-35.35534,-
1.3,-50,-1.3
vsbw,1
wplane,1,1.3,0,-1.3,35.35534,0,-35.35534,1.3,-
50,-1.3
vsbw,6
lcomb,25,37
LSEL,S,LINE,,30
LESIZE,ALL,,12
ALLSEL

lsel,s,line,,22,35,13 1
esize,all,,12
allsel
LSEL,S,LINE,,38
LESIZE,ALL,,12
ALLSEL
mat,1
TYPE,1
mshk,1
msha,0,3D
esize,,12
vmesh,7
LCOMB,24,33
LSEL,S,LINE,,20
LESIZE,ALL,,4
ALLSEL
mat,1
TYPE,1
mshk,1
msha,0,3D
esize,,12
vmesh,5
mat,1
TYPE,1
mshk,1
msha,0,3D
esize,,12
vmesh,2
mat,1
TYPE,1
mshk,1
msha,0,3D
esize,,12
vmesh,3
mat,1
    
```

```

TYPE,1
mshk,1
msha,0,3D
esize,12
vmesh,4
mat,1
TYPE,1
mshk,1
msha,0,3D
esize,12
vmesh,1
inter=1e-6
wplane,1,0,-50,0,50,-50,0,0,0,0
blc4,-1.3,0,2.6,-8,-1.3
lsl,s,line,,39,44,5
lesize,all,,8
allsel
lsl,s,line,,48,49,1
lesize,all,,4
allsel
lsl,s,line,,33,40,7
lsl,a,line,,43,45,2
lesize,all,,4
allsel
mat,2
TYPE,1
mshk,1
msha,0,3D
esize,8
vmesh,6
!elementos de contacto!!
ASEL,S,AREA,,22
NSLA,,1
CM,CYL1,NODE
REAL,1
TYPE,3
MAT,3
ESURF
allsel
ASEL,S,AREA,,28
NSLA,,1
CM,CYL2,NODE
REAL,1
TYPE,2
ESURF
ALLSEL
!!condiciones de contorno!!
nsl,s,loc,y,0
nsl,r,loc,z,0
d,all,ux,0
D,ALL,UZ,0
ALLSEL
nsl,s,loc,y,0
nsl,r,loc,x,0,0.27006e-9
d,all,uz,0
D,ALL,UX,0
ALLSEL
NSEL,S,LOC,Z,0
D,ALL,UZ,0
allsel
VSEL,S,VOLU,,6
NSLV,S,1
NSEL,R,LOC,Y,-50
d,all,uy
ALLSEL
VSEL,S,VOLU,,6
NSLV,S,1
NSEL,R,LOC,Y,-58
D,ALL,UY
ALLSEL
VSEL,S,VOLU,,6
NSLV,S,1
nsl,R,loc,y,-58,-50
NSEL,r,LOC,X,-1.3
D,ALL,UX
ALLSEL
VSEL,S,VOLU,,6
NSLV,S,1
nsl,R,loc,y,-58,-50
NSEL,r,LOC,X,1.3
D,ALL,UX
ALLSEL
VSEL,S,VOLU,,6
NSLV,S,1
nsl,R,loc,y,-58,-50
NSEL,r,LOC,Z,-1.3
D,ALL,UZ
ALLSEL
VSEL,S,VOLU,,6
NSLV,S,1
nsl,R,loc,y,-58,-50
NSEL,r,LOC,Z,0
D,ALL,UZ
allsel
ADELE,4
ADELE,2
LDELE,5,6,1
FINISH
!!fin del preprocesador!!
/SOLU
nsl,s,loc,y,0,0.61257E-14
D,all,UY,-0.0175
allsel
SOLVE
FINISH

```

ESFERA-ESFERA

SUPERFICIE-A-SUPERFICIE, MALLAS NO COINCIDENTES Y CARGA HORIZONTAL

```

/PREP7
!tipos de elementos y propiedades!!
ET,1,SOLID45
ET,2,TARGE170
ET,3,CONTA174
keyopt,3,5,1
MP,EX,1,0.1e5
MP,NUXY,1,0.30
mp,ex,2,0.1e8
mp,nuxy,2,0.30
mp,mu,3,0.2
!!modelado y mallado!!
wplane,1,0,0,0,1,0,0,0,1
sphere,50,0,0,-180
wplane,1,-50,0,-50,50,0,-50,-50,0,0
vsbw,all
vdele,3
wplane,1,0,-50,0,50,-50,0,0,50,0
wplane,1,-50,50,-1.3,50,50,-1.3,-50,0,-1.3
vsbw,2
wplane,1,-1.3,50,-1.3,-1.3,50,0,-1.3,0,-1.3
vsbw,3
wplane,1,1.3,50,-1.3,1.3,50,0,1.3,0,-1.3
vsbw,4
wplane,1,-1.3,0,-1.3,-35.35534,0,-35.35534,-
1.3,-50,-1.3
vsbw,1
wplane,1,1.3,0,-1.3,35.35534,0,-35.35534
,1.3,-50,-1.3
vsbw,6
wplane,1,0,0,0,1,0,0,0,1,0
wplane,1,0,-100,0,50,-100,0,-150,0
wplane,1,0,-100,0,0,-150,0,0,-100,50
sphere,50,0,0,-180
wplane,1,-50,-100,-50,50,-100,-50,-50,-100,0
vsbw,6
vdele,9
wplane,1,0,-100,0,50,-100,0,0,-50,0
wplane,1,-50,-100,-1.3,50,-100,-1.3,-50,-50,-
1.3
vsbw,8
wplane,1,-1.3,-100,0,-1.3,-100,-1.3,-1.3,-50,0
vsbw,9
wplane,1,1.3,-100,0,1.3,-100,-1.3,1.3,-50,0
vsbw,10
wplane,1,-1.3,-100,-1.3,-35.35534,0,-100,-
35.35534,-1.3,-50,-1.3
vsbw,6
wplane,1,1.3,-100,-1.3,35.35534,0,-100,-
35.35534,-1.3,-50,-1.3
vsbw,12
lsel,s,line,,38
lesize,all,,8
allsel
lcomb,25,37
LSEL,S,LINE,,30
LESIZE,ALL,,12
ALLSEL
lsel,s,line,,22,35,13
lesize,all,,12
allsel
LSEL,S,LINE,,38
LESIZE,ALL,,12
ALLSEL
mat,1
TYPE,1
mshk,1
msha,0,3D
esize,,12
vmesh,7
lcomb,61,74
LSEL,S,LINE,,30
LESIZE,ALL,,8
ALLSEL
lsel,s,line,,22,35,13
lesize,all,,8
allsel
LSEL,S,LINE,,38
LESIZE,ALL,,8
ALLSEL
mat,2
TYPE,1
mshk,1
msha,0,3D
esize,,8
vmesh,13
LCOMB,24,33
LSEL,S,LINE,,20
LESIZE,ALL,,4
ALLSEL
mat,1
TYPE,1
mshk,1
msha,0,3D
esize,,12
vmesh,5

```

```

LCOMB,62,70
LSEL,S,LINE,,58
LESIZE,ALL,,2
ALLSEL
mat,2
TYPE,1
mshk,1
msha,0,3D
esize,8
vmesh,11
mat,1
TYPE,1
mshk,1
msha,0,3D
esize,12
vmesh,2
mat,2
TYPE,1
mshk,1
msha,0,3D
esize,8
vmesh,8
mat,1
TYPE,1
mshk,1
msha,0,3D
esize,12
vmesh,3
mat,2
TYPE,1
mshk,1
msha,0,3D
esize,8
vmesh,9
mat,1
TYPE,1
mshk,1
msha,0,3D
esize,12
vmesh,4
mat,2
TYPE,1
mshk,1
msha,0,3D
esize,8
vmesh,10
mat,1
TYPE,1
mshk,1
msha,0,3D
esize,12
vmesh,1
mat,2
TYPE,1
mshk,1
msha,0,3D
esize,8
vmesh,6
!!elementos de contacto!!
ASEL,S,AREA,,22
NSLA,,1
CM,CYL1,NODE
REAL,1
TYPE,3
MAT,3
ESURF
ASEL,S,
AREA,,46
NSLA,,1
CM,CYL2,NODE
REAL,1
TYPE,2
ESURF
ALLSEL
;;condiciones de contorno!!
nset,s,loc,y,0
nset,r,loc,z,0
!d,all,ux,0
D,ALL,UZ,0
ALLSEL
nset,s,loc,y,0
nset,r,loc,x,-0.23140E-10,0.12439E-08
d,all,uz,0
D,ALL,UX,0.001
ALLSEL
NSEL,S,LOC,Z,0
D,ALL,UZ,0
nset,s,loc,y,-100
nset,r,loc,z,0
d,all,ux,0
D,ALL,UZ,0
ALLSEL
nset,s,loc,y,-100
nset,r,loc,x,-0.23140E-10,0.12439E-08
d,all,uz,0
D,ALL,UX,0
ALLSEL
nset,s,loc,y,-100
d,all,uy allsel
ADELE,4
adele,28
ADELE,2
adele,23
LDELE,5,6,1
ldele,42,43,1
FINISH
!!fin del pre-procesador!!
/SOLU
nset,s,loc,y,0,0.61257E-14
d,all,uY,-0.03

```

```
allsel  
autots,on,on  
nsbust,1,10,1  
  
SOLVE  
  
FINISH
```