SURFACE OF REVOLUTION to PLANE CONTACT

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ABSTRACT:

A user-friendly method of defining intermittent contact between a Surface of Revolution (SOR) and an 'infinite' plane.

Description of Technique: .

The Body 313 Euler angles used in ADAMS to represent angular displacement can be difficult to understand, but some properties make it particularly useful for determining forces arising from the interaction of the SOR and a plane.

Body 313 Euler angles.

Euler angles consist of three consecutive rotations about specified axes. The 313 refers to the axes that the rotations are to be about, in this case the first rotation is about the axis designated 3, the second rotation about the 1, and the third rotation about the 3 axis again.

The designation of Body on the Euler angles is in reference to which axes the rotation is taking place about. There are two commonly accepted possibilities, those being Body or fixed. Body refers to the axes on the body being rotated, while fixed refers to the axes of the frame of reference. Thus, Body 313 Euler angles give the orientation of the body by rotating the body first around its z axis, then around its x axis, and finally around its z axis.

A consequence of this choice of rotations to determine orientation is that after the first two rotations, the body has its z axis fixed with respect to the fixed frame. The second rotation about the x axis of the body determines the inclination of the body x-y plane with respect to the fixed frame. This angle is known as THETA. While the orientation can be represented with THETA as either positive or negative, ADAMS always calculates this angle as positive.

If the body is considered to be a disk of radius R in the x-y plane, then the point with the lowest z coordinate in the fixed frame will lay at $-|R|$ on the body's y axis after the second rotation. Since the body is symmetrical along it's z axis, the third Euler angle can be discarded in determining the location of the contact.

Thus, by defining the SOR as a sequence of these stacked disks, and summing the forces and torques from each disks unique contact point, the total force and torques can be determined and applied using a single GFOSUB.

Implementation:

The following elements are needed in the dataset to define the SOR to plane contact forces.

Definition of SOR.

The profile of the SOR is given in two ARRAY statements. One ARRAY statements contain ***R***, the radius of the disk, while the second contains the distance from the center of the disk on the z axis to the body referenced origin (0,0,0). The first and last data points should be repeated with a negative value for the radius. This avoids problems caused by contact at the top or bottom of the **SOR**.

(It is possible to put this information into one ARRAY statement, but the FORTRAN would need to be rewritten) Currently the interpolation between data points is assumed to be linear. This is easy to change, and the current subroutine also has an option for the user to determine the contact point, which will not be further documented here.

Definition of The Contact Plane.

The plane is defined by a MARKER, with the z axis of the MARKER being the normal for the plane. The GFORCE will use this MARKER as the Reference Marker (RM). As the routine makes use of the IMPACT subroutine, the RM is usually displaced a short distance (FL) from the origin along the negative z axis.

Definition of The GFORCE.

The I MARKER for the GFORCE should be located at the origin of the **SOR** profile.

The RM MARKER may be placed anywhere in the x-y plane, but should be displaced a distance of FL as noted above.

The JFLOAT MARKER should be placed on the PART serving as the plane.

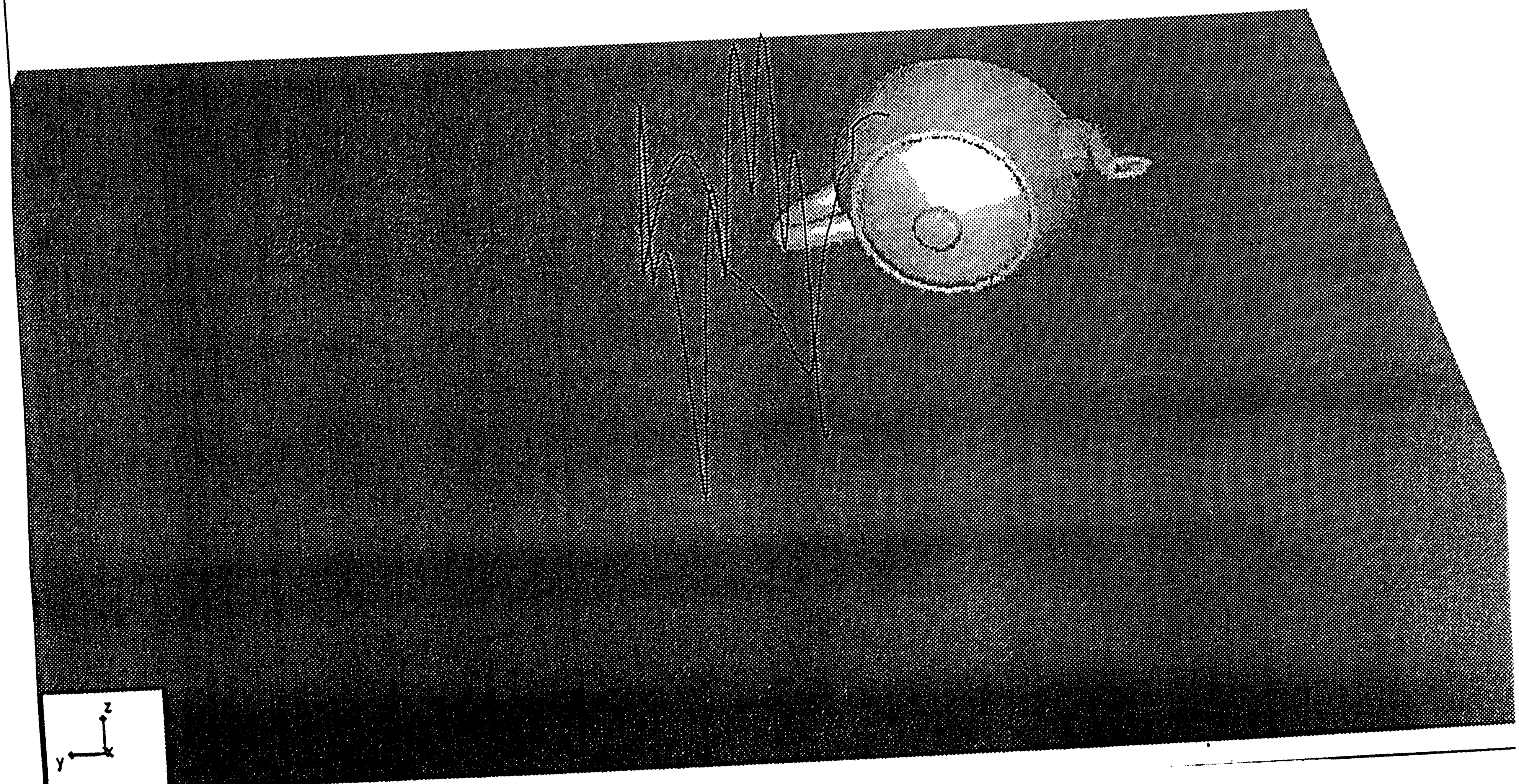
The USER function should contain the following:

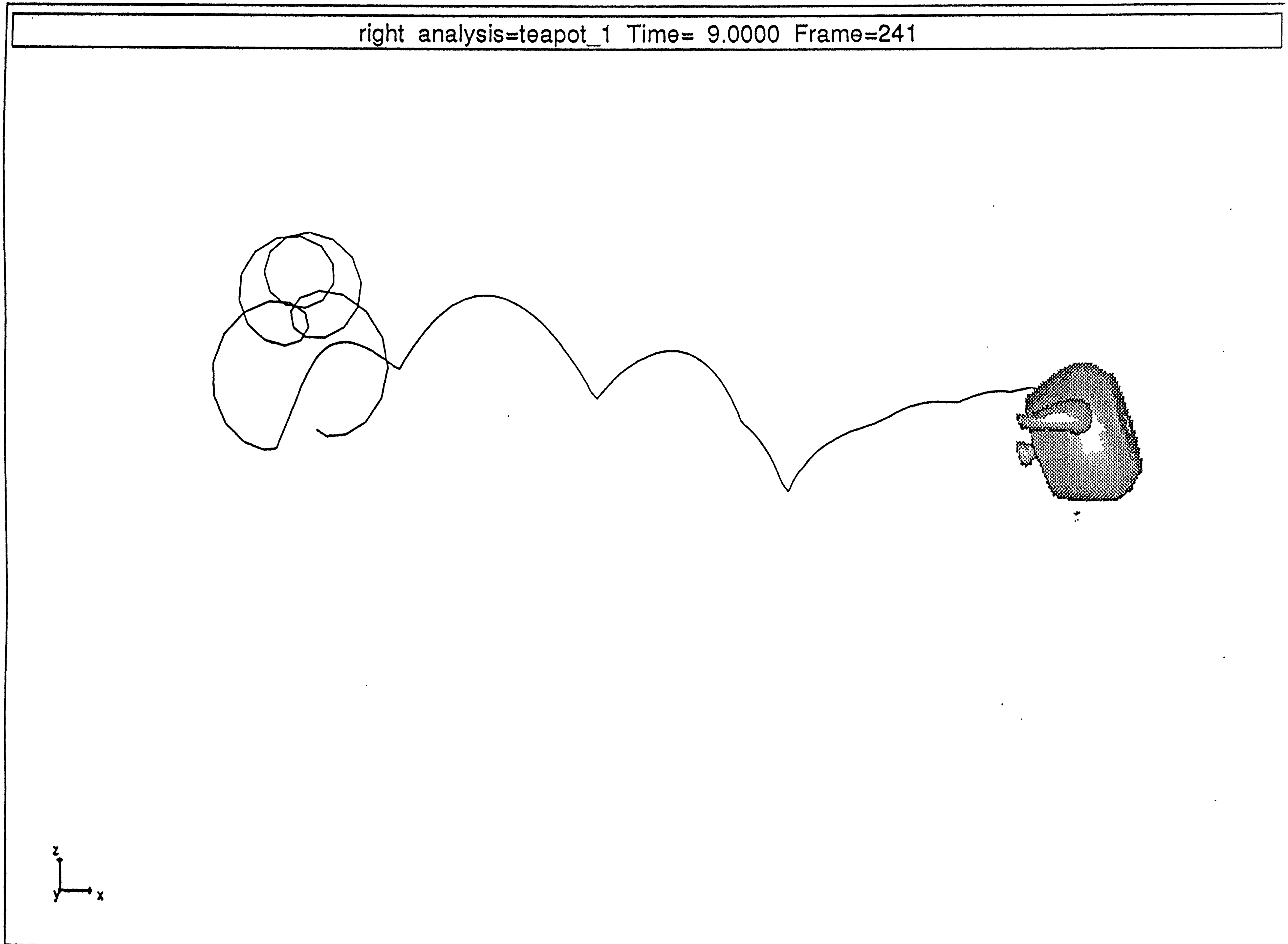
PAR#	Subroutine Variable	Explanation
1	CONTAC	Branch to Contact routines. Set to 1.
2	WHICH	Contact determination switching Set to 1 for **SOR** to plane.
3	NUMARY	# of possible contact points. (# of points in profile)

PAR#	Subroutine Variable	Explanation
4	MARI	GFORCE I MARKER.
5	MARREF	GFORCE RM MARKER.
6	IDARY	ID of ARRAY for *R*. (ID of ARRAY for z displacement is IDARY+1)
7	FL	-Free length- of IMPACT. (Distance of RM along negative z axis)
8	SK	Contact Stiffness.
9	E	Exponent of displacement in IMPACT.
10	C	Vertical Damping Coefficient for IMPACT.
11	DEPTH	Penetration depth for full damping.
12	COEFFR	Coefficient of coulomb friction (STAT)
13	NUMSLI	Not used for linear approx.
14	IDVARR	Not used for linear approx.
15	VELSTA	Velocity for static friction.
16	VELSLI	Velocity for sliding friction.
17	CFRSLI	Coefficient for sliding friction.

Attached is the dataset for the coffee pot and the subroutine surrev2.f This model can be viewed in AVIEW 7.0, by reading in the demo.bin file and picking DEMO from the fixed menus, then FEATURE -> IMPACT -> LOAD_DEMO and finally choosing TEAPOT.

right analysis=teapot_1 Time= 9.0000 Frame=241




right analysis=teapot_1 Time= 9.0000 Frame=241
z
y
x

```
      SUBROUTINE GFOSUB(ID,TIME,PAR,NPAR,DFLAG,IFLAG,RESULT)
C23456789112345678921234567893123456789412345678951234567896123456789712
      INTEGER                 ID, NPAR,IPAR(3)
      DOUBLE PRECISION        TIME
      DOUBLE PRECISION        PAR(NPAR)
      LOGICAL                 DFLAG
      LOGICAL                 IFLAG
      DOUBLE PRECISION        RESULT(6),FMDISP(6),FMVEL(6)
      DOUBLE PRECISION        ZARYVA(100),RARYVA(100),A31(3)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      SAVE
C
C
C    This subroutine is the same as surrevl, with the following
C    exceptions:
C
C      1. This subroutine allows variable calculation of n
C         contact points, on the - Y axis, in the dataset.
C
C      2. This subroutine models coulomb friction, both sliding
C         and static. A static velocity and dynamic velocity
C         is required.
C
C
C   PARAMETER LIST
C
C   PAR #        VARIABLE      EXPLN.
C
C    1           CONTAC        SWITCH TO CONTACT SUBROUTINE PORTION
C    2           WHICH         TYPE OF CONTACT.
C    3           NUMARY        # OF POSSIBLE CONTACT POINTS.
C    4           MARI          GFO I MARKER.
C    5           MARREF        GFO RM MARKER
C    6           IDARY         ARRY OF R DISP FROM I.
C    7           FL            -FREE LENGTH- OF IMPACT.
C    8           SK            STIFFNESS.
C    9           E             EXPONENT OF DISPLACEMENT IN IMPACT
C   10           C             VERTICAL DAMPING COEFFICIENT.
C   11           DEPTH         PENETRATION DEPTH FOR FULL DAMPING.
C   12           COEFFR        COEFFICIENT OF COULOMB FRICTION (STAT).
C   13           NUMSLI        NUMBER OF SLIDING PT CONTACTS.
C   14           IDVARR        ID OF VARIABLE GIVING R (+1 Z)
C   15           VELSTA        VELOCITY FOR STATIC FRIC. MAX.
C   16           VELSLI        VELOCITY FOR SLIDING FRIC MIN.
C   17           CFRSLI        COEFFICIENT OF SLIDING FRICTION.
C
      IPAR(1)=PAR(4)
      IPAR(2)=PAR(5)
      IPAR(3)=PAR(5)
      CALL SYSARY('DISP',IPAR,3,FMDISP,6,ERRFLG)
      CALL ERRMES(ERRFLG,'ERROR IN FMDISP',ID,STOP)
      CALL SYSARY('VEL',IPAR,3,FMVEL,6,ERRFLG)
      CALL ERRMES(ERRFLG,'ERROR IN FMVEL',ID,STOP)
      DX=   FMDISP(1)
      DY=   FMDISP(2)
```

```
        DZ=   FMDISP(3)
C      write(*,10)dx,dz
        PSI=  FMDISP(4)
        THETA=FMDISP(5)
        PHI=  FMDISP(6)
C      write(*,10)psi,theta
        VX=   FMVEL(1)
        VY=   FMVEL(2)
        VZ=   FMVEL(3)
        WX=   FMVEL(4)
        WY=   FMVEL(5)
        WZ=   FMVEL(6)
        IF (PAR(2).eq.2) THEN
          DO 20 I=PAR(3)+1,PAR(3)+PAR(13)
           IPAR(1)=PAR(14)
           CALL SYSFNC('VARVAL',IPAR,1,TEM,ERRFLG)
           CALL ERRMES(ERRFLG,'error in VARr',ID,STOP)
           RARYVA(I)=TEM
           IPAR(1)=PAR(14)+1
           CALL SYSFNC('VARVAL',IPAR,1,TEM,ERRFLG)
           CALL ERRMES(ERRFLG,'error in VARz',ID,STOP)
           ZARYVA(I)=TEM
 20       CONTINUE
        ENDIF
C
C
C
C
      IF (IFLAG) THEN
            IDARYR=PAR(6)
            CALL GTARAY(IDARYR,RARYVA,MU,ISTAT)
            IDARYZ=PAR(6)+1
            CALL GTARAY(IDARYZ,ZARYVA,MU,ISTAT)
C            WRITE(*,10)zaryva(1),zaryva(4)
  10        format(f10.7)
            CONTAC=PAR(1)
            WHICH= PAR(2)
            NUMARY=PAR(3)
            MARI=  PAR(4)
            MARREF=PAR(5)
            IDARY =PAR(6)
            FL=    PAR(7)
            SK=    PAR(8)
            E=     PAR(9)
            C=     PAR(10)
            DEPTH= PAR(11)
            COEFFR=PAR(12)
C            WRITE(*,10)CONTAC
C            WRITE(*,10)WHICH
C            WRITE(*,11)NUMARY
C            WRITE(*,11)MARI
C            WRITE(*,11)MARREF
C            WRITE(*,11)IDARY
C            WRITE(*,10)FL
C            WRITE(*,10)SK
C            WRITE(*,10)E
```

```
C             WRITE(*,10)C
C             WRITE(*,10)DEPTH
C             WRITE(*,10)COEFFR
  11         format(I5)
      ELSE
C             WRITE(*,10)zaryva(1),zaryva(5)
            RESULT(1)=0
            RESULT(2)=0
            RESULT(3)=0
            RESULT(4)=0
            RESULT(5)=0
            RESULT(6)=0
C23456789112345678921234567893123456789412345678951234567896123456789712
       IF (WHICH.eq.2) THEN
           MORE=PAR(13)
       ELSEIF (WHICH.EQ.1) THEN
           MORE=0
       ENDIF
           DO 50 I=1,PAR(3)+MORE
               TEM=ZARYVA(I)*DSIN(THETA)+RARYVA(I)*DCOS(THETA)
               A11=TEM*DSIN(PSI)
               A12=-TEM*DCOS(PSI)
               A13=ZARYVA(I)*DCOS(THETA)-RARYVA(I)*DSIN(THETA)
               A21=VX+WY*A13-WZ*A12
               A22=VY+WZ*A11-WX*A13
               A23=VZ+WX*A12-WY*A11
               A14=DZ+A13
C               WRITE(*,10)A13,A14
               CALL IMPACT(A14,A23,FL,SK,E,C,DEPTH,IORD,A31,ERRFLG)
               CALL ERRMES(ERRFLG,'ERROR IN FMDISP',ID,STOP)
               A32=A31(1)*(RARYVA(I)*DCOS(THETA)+ZARYVA(I)*DSIN(THETA))
               A41=DATAN2(A22,A21)
               A42=DSQRT(A21**2+A22**2)
               T1=-PAR(15)
               T2=-1.0
               T3=PAR(15)
               T4=1.0
               CALL STEP(A42,T1,T2,T3,T4,IORD,TEM1,ERRFLG)
               CALL ERRMES(ERRFLG,'ERROR IN step',ID,STOP)
               T1=PAR(15)
               T2=COEFFR
               T3=PAR(16)
               T4=PAR(17)
               CALL STEP(A42,T1,T2,T3,T4,IORD,TEM2,ERRFLG)
               CALL ERRMES(ERRFLG,'ERROR IN step',ID,STOP)
               TEM=A31(1)*TEM1*TEM2
               A43=-TEM*DCOS(A41)
               A44=-TEM*DSIN(A41)
               A91=-A32*DCOS(PSI)-A44*A13
               A92=-A32*DSIN(PSI)+A43*A13
               A93=-A43*A12+A44*A11
               RESULT(1)=RESULT(1)+A43
               RESULT(2)=RESULT(2)+A44
               RESULT(3)=RESULT(3)+A31(1)
               RESULT(4)=RESULT(4)+A91
               RESULT(5)=RESULT(5)+A92
```

```
                RESULT(6)=RESULT(6)+A93
 50         CONTINUE
          ENDIF
        RETURN
        END
```

```
ADAMS/View model name: MOD1
!
!-------------------------------- PARTS -----------------------------------
!
!     This dataset uses the FORTRAN from surrev2.f. It also uses the teapot.shl
!     file for animation in View. It's a killer demo for surface contact via
!     surface of revolution to plane contact.
!
!-------------------------------- Ground ----------------------------------
!
!                              adams_view_name='ground'
PART/1
, GROUND
!
!                              adams_view_name='MAR1'
MARKER/1
, PART = 1
, QP = 0, -1.79435575, -0.0525514297
, REULER = 90D, 90D, 0D
!
!                              adams_view_name='MAR3'
MARKER/3
, PART = 1
!
!                              adams_view_name='FMA4'
MARKER/4
, PART = 1
, FLOATING
!
!                              adams_view_name='FMA22'
MARKER/22
, PART = 1
, FLOATING
!
!                              adams_view_name='FMA23'
MARKER/23
, PART = 1
, FLOATING
!
!                              adams_view_name='FMA24'
MARKER/24
, PART = 1
, FLOATING
!
!                              adams_view_name='FMA25'
MARKER/25
, PART = 1
, FLOATING
!
!                              adams_view_name='FMA26'
MARKER/26
, PART = 1
, FLOATING
!
!                              adams_view_name='FMA27'
MARKER/27
```

```
, PART = 1
, FLOATING
!
!                               adams_view_name='FMA28'
MARKER/28
, PART = 1
, FLOATING
!
!                               adams_view_name='FMA29'
MARKER/29
, PART = 1
, FLOATING
!
!                               adams_view_name='FMA30'
MARKER/30
, PART = 1
, FLOATING
!
!                               adams_view_name='FMA31'
MARKER/31
, PART = 1
, FLOATING
!
!                               adams_view_name='FMA32'
MARKER/32
, PART = 1
, FLOATING
!
!                               adams_view_name='FMA33'
MARKER/33
, PART = 1
, FLOATING
!
!                               adams_view_name='FMA34'
MARKER/34
, PART = 1
, FLOATING
!
!                               adams_view_name='FMA35'
MARKER/35
, PART = 1
, FLOATING
!
!                               adams_view_name='FMA36'
MARKER/36
, PART = 1
, FLOATING
!
!                               adams_view_name='FMA37'
MARKER/37
, PART = 1
, FLOATING
!
!                               adams_view_name='FMA38'
MARKER/38
, PART = 1
```

```
, FLOATING
!
!                              adams_view_name='BOX1'
GRAPHICS/1
, BOX
, CORNER = 1
, X = 3.594575048
, Y = 0.0508852103
, Z = 0.1017704206
!
!----------------------------------- Part ------------------------------------
!
!                              adams_view_name='PAR2'
PART/2
,mass=1
,ip=1,1,1
,cm=200
,qg=0,0,3
,vx=1,vy=1
,reu=90d,70d,-90d

MARKER/200,qp=0,0,1.21

!
!                              adams_view_name='MAR2'
MARKER/2
, PART = 2
!
!                              adams_view_name='tip'
MARKER/5
, PART = 2
, QP = 3.127000113, 0, 2.466999924
, REULER = 270D, 3.5D, 90D
!
!                              adams_view_name='t1'
MARKER/6
, PART = 2
, QP = 2.757999897, 0, 2.187999964
, REULER = 90D, 9.5D, 270D
!
!                              adams_view_name='t2'
MARKER/7
, PART = 2
, QP = 2.630000114, 0, 1.914999962
, REULER = 90D, 29D, 270D
!
!                              adams_view_name='t3'
MARKER/8
, PART = 2
, QP = 2.536999941, 0, 1.621999979
, REULER = 90D, 47.5D, 270D
!
!                              adams_view_name='t4'
MARKER/9
, PART = 2
, QP = 2.404000044, 0, 1.347000003
```

```
, REULER = 90D, 62.5D, 270D
!
!                                adams_view_name='t5'
MARKER/10
, PART = 2
, QP = 2.151000023, 0, 1.131000042
, REULER = 90D, 76D, 270D
!
!                             adams_view_name='handtop'
MARKER/11
, PART = 2
, QP = -1.940999985, 0, 2.135999918
, REULER = 90D, 81D, 270D
!
!                                adams_view_name='h1'
MARKER/12
, PART = 2
, QP = -2.265000105, 0, 2.125
, REULER = 90D, 57D, 270D
!
!                                adams_view_name='h2'
MARKER/13
, PART = 2
, QP = -2.519000053, 0, 2.095000029
, REULER = 90D, 42D, 270D
!
!                                adams_view_name='h3'
MARKER/14
, PART = 2
, QP = -2.701999903, 0, 2.036999941
, REULER = 90D, 31.5D, 270D
!
!                                adams_view_name='h4'
MARKER/15
, PART = 2
, QP = -2.812999964, 0, 1.942000032
, REULER = 90D, 18D, 270D
!
!                                adams_view_name='h5'
MARKER/16
, PART = 2
, QP = -2.849999905, 0, 1.799999952
, REULER = 360D, 0D, 0D
!
!                                adams_view_name='h6'
MARKER/17
, PART = 2
, QP = -2.826999903, 0, 1.625
, REULER = 270D, 17D, 90D
!
!                                adams_view_name='h7'
MARKER/18
, PART = 2
, QP = -2.756000042, 0, 1.440000057
, REULER = 270D, 31D, 90D
!
```

```
!                                      adams_view_name='h8'
MARKER/19
, PART = 2
, QP = -2.634000063, 0, 1.253999949
, REULER = 270D, 45D, 90D
!
!                                      adams_view_name='h9'
MARKER/20
, PART = 2
, QP = -2.460999966, 0, 1.072000027
, REULER = 270D, 63.5D, 90D
!
!                                      adams_view_name='h10'
MARKER/21
, PART = 2
, QP = -2.233999968, 0, 0.90200001
, REULER = 270D, 86.5D, 90D
!
!------------------------------------ FORCES ------------------------------------
!                R disp.
ARRAY/1,NUMBERS=-0.4352445214
, 0.4352445214
, 0.9826136371
, 1.2723592259
, 1.4255045358
, 1.4879163584
, 1.4989875794
, 1.5358454605
, 1.6318627562
, 1.7527556583
, 1.8773276589
, 1.9686561016
, 2.0076203445
, 1.9905832629
, 1.9372742547
, 1.8568764775
, 1.7627508985
, 1.6465024219
, 1.5248120939
, 1.4896702002
, 1.4552587329
, 1.4262695848
, 1.3793452586
, 0.3216196632
, 0.201800484
, 0.2207196241
, 0.3027009105
, 0.3531512951
, 0.2585571443
,-0.2585571443

ARRAY/2,NUMBERS=-4.3654266526E-03
,-4.3654266526E-03
, 4.7573867838E-03
, 2.7330734918E-02
, 5.7429600873E-02
```

```
, 9.2163808866E-02
, 0.1295483197
, 0.1773903579
, 0.2557136745
, 0.3605724833
, 0.4990842619
, 0.6688679891
, 0.8761223846
, 1.1085660558
, 1.3510008227
, 1.6006561404
, 1.8587425804
, 2.1142828736
, 2.3781722167
, 2.434688473
, 2.4669770458
, 2.4780696637
, 2.4790034825
, 2.617886358
, 2.662076288
, 2.8325234
, 2.933528954
, 3.034534508
, 3.103976065
, 3.103976065
!                              adams_view_name='GFO1'
GFORCE/1
, I = 2
, JFLOAT = 4
, RM = 3
, FUNCTION = USER(1,1,30,2,3,1,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!                    R ARRAY
ARRAY/3,NUMBERS=-.15,.15
ARRAY/4,NUMBERS=0,0
!                              adams_view_name='GFO2'
GFORCE/2
, I = 5
, JFLOAT = 22
, RM = 3
, FUNCTION = USER(1,1,2,5,3,3,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!                    R ARRAY
ARRAY/5,NUMBERS=-.21,21
ARRAY/6,NUMBERS=0,0
!                              adams_view_name='GFO3'
GFORCE/3
, I = 6
, JFLOAT = 23
, RM = 3
, FUNCTION = USER(1,1,2,6,3,5,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!                    R ARRAY
ARRAY/7,NUMBERS=-.267,.267
ARRAY/8,NUMBERS=0,0
!                              adams_view_name='GFO4'
```

```
GFORCE/4
, I = 7
, JFLOAT = 24
, RM = 3
, FUNCTION = USER(1,1,2,7,3,7,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!
ARRAY/9,NUMBERS=-.341,.341
ARRAY/10,NUMBERS=0,0
!                              adams_view_name='GFO5'
GFORCE/5
, I = 8
, JFLOAT = 25
, RM = 3
, FUNCTION = USER(1,1,2,8,3,9,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!
ARRAY/11,NUMBERS=-.415,.415
ARRAY/12,NUMBERS=0,0
!                              adams_view_name='GFO6'
GFORCE/6
, I = 9
, JFLOAT = 26
, RM = 3
, FUNCTION = USER(1,1,2,9,3,11,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!
ARRAY/13,NUMBERS=-.472,.472
ARRAY/14,NUMBERS=0,0
!                              adams_view_name='GFO7'
GFORCE/7
, I = 10
, JFLOAT = 27
, RM = 3
, FUNCTION = USER(1,1,2,10,3,13,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!
ARRAY/15,NUMBERS=-.225,.225
ARRAY/16,NUMBERS=0,0
!                              adams_view_name='GFO8'
GFORCE/8
, I = 11
, JFLOAT = 28
, RM = 3
, FUNCTION = USER(1,1,2,11,3,15,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!
ARRAY/17,NUMBERS=-.225,.225
ARRAY/18,NUMBERS=0,0
!                              adams_view_name='GFO9'
GFORCE/9
, I = 12
, JFLOAT = 29
, RM = 3
, FUNCTION = USER(1,1,2,12,3,17,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
```

```
!
ARRAY/19,NUMBERS=-.225,.225
ARRAY/20,NUMBERS=0,0
!                             adams_view_name='GFO10'
GFORCE/10
, I = 13
, JFLOAT = 30
, RM = 3
, FUNCTION = USER(1,1,2,13,3,19,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!
ARRAY/21,NUMBERS=-.225,.225
ARRAY/22,NUMBERS=0,0
!                             adams_view_name='GFO11'
GFORCE/11
, I = 14
, JFLOAT = 31
, RM = 3
, FUNCTION = USER(1,1,2,14,3,21,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!
ARRAY/23,NUMBERS=-.225,.225
ARRAY/24,NUMBERS=0,0
!                             adams_view_name='GFO12'
GFORCE/12
, I = 15
, JFLOAT = 32
, RM = 3
, FUNCTION = USER(1,1,2,15,3,23,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!
ARRAY/25,NUMBERS=-.225,.225
ARRAY/26,NUMBERS=0,0
!                             adams_view_name='GFO13'
GFORCE/13
, I = 16
, JFLOAT = 33
, RM = 3
, FUNCTION = USER(1,1,2,16,3,25,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!
ARRAY/27,NUMBERS=-.225,.225
ARRAY/28,NUMBERS=0,0
!                             adams_view_name='GFO14'
GFORCE/14
, I = 17
, JFLOAT = 34
, RM = 3
, FUNCTION = USER(1,1,2,17,3,27,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!
ARRAY/29,NUMBERS=-.225,.225
ARRAY/30,NUMBERS=0,0
!                             adams_view_name='GFO15'
GFORCE/15
, I = 18
```

```
, JFLOAT = 35
, RM = 3
, FUNCTION = USER(1,1,2,18,3,29,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!
ARRAY/31,NUMBERS=-.225,.225
ARRAY/32,NUMBERS=0,0
!                               adams_view_name='GFO16'
GFORCE/16
, I = 19
, JFLOAT = 36
, RM = 3
, FUNCTION = USER(1,1,2,19,3,31,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!
ARRAY/33,NUMBERS=-.225,.225
ARRAY/34,NUMBERS=0,0
!                               adams_view_name='GFO17'
GFORCE/17
, I = 20
, JFLOAT = 37
, RM = 3
, FUNCTION = USER(1,1,2,20,3,33,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!
ARRAY/35,NUMBERS=-.225,.225
ARRAY/36,NUMBERS=0,0
!                               adams_view_name='GFO18'
GFORCE/18
, I = 21
, JFLOAT = 38
, RM = 3
, FUNCTION = USER(1,1,2,21,3,35,1,1e4,1.25,1e+1,1e-2,.9,0,0,1,5,.3)
!
!------------------------------ ANALYSIS SETTINGS --------------------------------
!
OUTPUT/
, REQSAVE
, GRSAVE
!
RESULTS/
, FORMATTED
!
!--------------------------------- SYSTEM UNITS ----------------------------------
!
ACCGRAV/KGRAV=-9.80665
!
UNITS/
, FORCE = NEWTON
, MASS = KILOGRAM
, LENGTH = METER
, TIME = SECOND
!
END
```