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# *MoM* Periodic User Manual

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## Introduction

*MoMPeriodic* calculates the currents upon and scattered fields radiated from a discrete periodic PEC structure. Periodicity is assumed to be in  $\phi$  where a single slice is repeated around the  $\phi$ -axis  $N$  times to generate the structure. Examples of periodic structures include helicopter rotors and engines.

The code uses only a single slice of the discrete periodic geometry to compute scattering from the entire body. As a result, it requires only  $1/N^2$  as much memory as similar codes requiring the entire geometry. CPU usage is reduced similarly. The incident field is assumed to be a plane wave, which is automatically decomposed into modes prior to calculation.

## Compilation

*MoMPeriodic* is written in object-oriented, highly streamlined Fortran90 source code. A Fortran90 compiler is required to build the program.

*MoMPeriodic* relies heavily on the latest numerical techniques, including BLAS for matrix manipulation and LAPACK for LU decomposition subroutines. Because numerical optimization of the routines above varies from platform to platform, we suggest that the user obtain libraries of these functions for their specific operating system. Most hardware manufacturers such as Intel, Sun, and SGI supply such numerical libraries free of charge. Check with your supplier for the availability of these libraries. If a generic implementation is desired for compatibility between various machines, platform-independent versions of these libraries can be found at [www.netlib.org](http://www.netlib.org). However, *MoMPeriodic*'s performance may suffer greatly without the benefit of optimized numerical libraries.

In summary, the following items are required to compile *MoMPeriodic*:

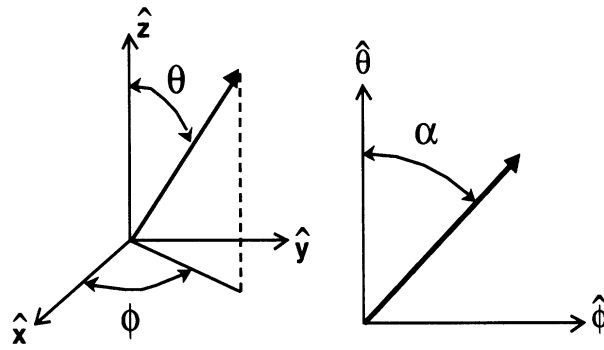
- *MoMPeriodic* FORTRAN 90 source files (\*.f90)
- FORTRAN 90 compiler
- BLAS numerical routines library
- LAPACK numerical routines library

## Execution

Before execution, the user must specify the incident angles of the plane wave excitation as well as the scattered-field look angles. These angles are all contained in the file INCIDENT.TXT, which must be located in the directory from which the program is executed. The first line of the INCIDENT.TXT file must contain the number of look angles. Each following line contains an angle specification for a single look angle. The syntax of the entire file is as follows, where the coordinate system is given in the diagram below:

```
<N = number of look angles>
< $\theta_i1$ > < $\phi_i1$ > < $\alpha1$ > < $\theta_s1$ > < $\phi_s1$ >
< $\theta_i2$ > < $\phi_i2$ > < $\alpha2$ > < $\theta_s2$ > < $\phi_s2$ >
.
.
.
```

$\langle \theta_i N \rangle \langle \phi_i N \rangle \langle \alpha N \rangle \langle \theta_s N \rangle \langle \phi_s N \rangle$



Coordinate System Reference

Please refer to the example below for a sample INCIDENT.TXT file.

When *MoMPeriodic* is executed, it will prompt for a series of parameters. These parameters are explained below.

**Geometry Input Filename**

This is the input file containing the geometry under test. The file must adhere to Tricode File Format specifications, which are given in Appendix A

**Slice spans what angle?**

Enter the angle of the slice measured along  $\phi$ . For instance, if the slice makes up 1/6 of the geometry the correct entry would be 60. If the slice makes up 1/4 of the geometry, the correct entry would be 90. If 360 is entered, the program will run a standard MoM analysis of the geometry.

**RCS Output Filename**

This is the name of the output file that will be produced. . Please see the section “Interpreting Results” below for more details.

**Maximum mode order?**

As part of the discrete body of revolution approach, the incident wave is broken down into a series of modes. Taking more modes into account increases the accuracy of the result. A good starting point for this parameter is 5.

**Interpreting Results**

The output file contains the description of the scattered far-field at each look angle. Each line of the output file contains the incident field angles, the scattered field angles, and the real and imaginary components of the vector field. The syntax of the file is as follows:

$\langle \theta_1 \rangle \langle \phi_1 \rangle \langle \alpha_1 \rangle \langle \theta_s 1 \rangle \langle \phi_s 1 \rangle \langle \text{Re}(E_{\theta 1}) \rangle \langle \text{Im}(E_{\theta 1}) \rangle \langle \text{Re}(E_{\phi 1}) \rangle \langle \text{Im}(E_{\phi 1}) \rangle$   
 $\langle \theta_2 \rangle \langle \phi_2 \rangle \langle \alpha_2 \rangle \langle \theta_s 2 \rangle \langle \phi_s 2 \rangle \langle \text{Re}(E_{\theta 2}) \rangle \langle \text{Im}(E_{\theta 2}) \rangle \langle \text{Re}(E_{\phi 2}) \rangle \langle \text{Im}(E_{\phi 2}) \rangle$   
 .  
 .  
 .  
 $\langle \theta_i N \rangle \langle \phi_i N \rangle \langle \alpha N \rangle \langle \theta_s N \rangle \langle \phi_s N \rangle \langle \text{Re}(E_{\theta N}) \rangle \langle \text{Im}(E_{\theta N}) \rangle \langle \text{Re}(E_{\phi N}) \rangle \langle \text{Im}(E_{\phi N}) \rangle$

Therefore, the vector E-field can be expressed from the above data as follows:

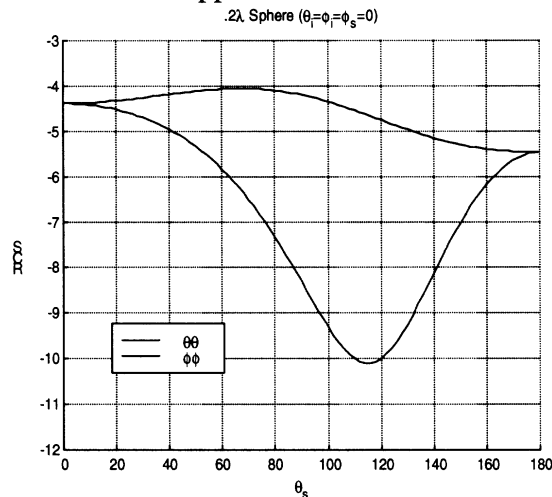
$$\mathbf{E}_n = \hat{\theta} \left( \langle \text{Re}(E_{\theta} n) \rangle + j \langle \text{Im}(E_{\theta} n) \rangle \right) + \hat{\phi} \left( \langle \text{Re}(E_{\phi} n) \rangle + j \langle \text{Im}(E_{\phi} n) \rangle \right)$$

## Example Run

The *MoMPeriodic* distribution package contains the files necessary to reproduce a sphere test geometry. The files involved are:

- Sphere\_Slice\_Geometry.txt: The *MoMPeriodic*-format file describing the sphere geometry
- Incident.txt: The incident angle file containing the bistatic view angles
- Sphere\_Slice\_Output.txt: The output file produced by running *MoMPeriodic*
- Sphere.pdf: A summary of results and visualization of the sphere geometry

The calculated RCS patterns should appear as follows:



To reproduce these results, use the following inputs to the program:

```
MoMPeriodic - Periodic MoM with RWG Basis Functions
Written by Michael Carr, University of Michigan, Radiation Laboratory
```

```
Geometry input filename? Sphere_Slice_Geometry.txt
Slice spans what angle (deg)? 60
RCS output filename? Sphere_Slice_Output.txt
Maximum mode order? 1
```

```
Slice spans 60.0 degrees, making 6 slices.
```

```
20 nodes requiring      240 bytes
24 faces requiring     960 bytes
43 edges requiring    1204 bytes
36 interior edges (unknowns)
```

```
Z-matrix:      10 KBytes.
Calculating modal order n= -1
Filling Z for slice 0
100% of zNear filled
Filling Z for slice 1
100% of zNear filled
Filling Z for slice 2
100% of zNear filled
Filling Z for slice 3
100% of zNear filled
Filling Z for slice 4
100% of zNear filled
Filling Z for slice 5
```

```
100% of zNear filled
  3.8 seconds to fill Z-matrix.
  0.0 seconds to LU-factorize Z-matrix.
Calculating modal order n=  0
Excitation vectors are identically zero. Skipping.
Calculating modal order n=  1
  Filling Z for slice  0
  100% of zNear filled
  Filling Z for slice  1
  100% of zNear filled
  Filling Z for slice  2
  100% of zNear filled
  Filling Z for slice  3
  100% of zNear filled
  Filling Z for slice  4
  100% of zNear filled
  Filling Z for slice  5
  100% of zNear filled
    3.9 seconds to fill Z-matrix.
    0.0 seconds to LU-factorize Z-matrix.
  0.7 seconds to solve for all look angles.
  9.4 seconds total.
```

## APPENDIX A – MoMPeriodic File Format Specification

**TRICODE file format** – The following document lists the file format created by Pam Haddad and expected by TRICODE/MOMFREE, MOMJET, AIMFREE, AIMJET, and others based on TRICODE.

1. The first line of the file holds the number of nodes and triangles.
2. The following lines give the x, y, and z coordinates (in order) of each node.
3. The next line holds the number of edges and the number of exterior edges.
4. Following that line are the interior edges, made up of pointers to the nodes. Note that the first node is indexed as 1 (one) and not 0 (zero). This format is more compatible for Fortran. The order in which the nodes are listed is unimportant.
5. The exterior edges follow in the same format.
6. Next are the triangles, made up of pointers to the edges. Note that the first edge is indexed as 1 (one). The order in which the edges are listed is unimportant.

Following is the format displayed in a programmer-friendly manner.

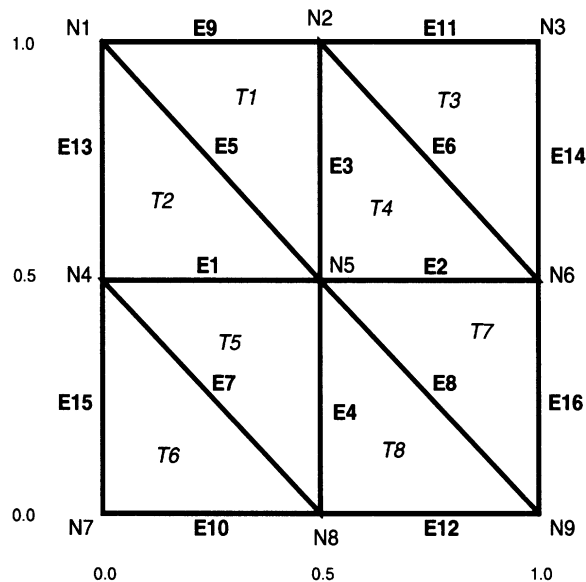
```

<n=number of nodes> <t=number of triangles>
<node #1 x coord> <node #1 y coord> <node #1 z coord>
<node #2 x coord> <node #2 y coord> <node #2 z coord>
.
.
.
<node #n x coord> <node #n y coord> <node #n z coord>
<e=number of edges>
<ex=number of exterior edges>
<interior edge #1 start node> <interior edge #1 end node>
<interior edge #2 start node> <interior edge #2 end node>
.
.
.
<interior edge #(e-ex) start node> <interior edge #(e-ex) end node>
<exterior edge #(e-ex+1) start node> <exterior edge #(e-ex+1) end node>
<exterior edge #(e-ex+2) start node> <exterior edge #(e-ex+2) end node>
.
.
.
<exterior edge #(e) start node> <exterior edge #(e) end node>
<triangle #1 edge1> <triangle #1 edge2> <triangle #1 edge3>
<triangle #2 edge1> <triangle #2 edge2> <triangle #2 edge3>
.
.
.
<triangle #t node1> <triangle #t node2> <triangle #t node3>

```

### EXAMPLE:

9 8	5 9
0.0 0.0 0.0	1 2
0.5 0.0 0.0	7 8
1.0 0.0 0.0	2 3
0.0 0.5 0.0	8 9
0.5 0.5 0.0	1 4
1.0 0.5 0.0	3 6
0.0 1.0 0.0	4 7
0.5 1.0 0.0	6 9
1.0 1.0 0.0	9 3 5
16 8	5 1 13
4 5	11 14 6
5 6	6 2 3
2 5	1 4 7
5 8	7 10 15
1 5	2 16 8
2 6	8 12 4
4 8	



# APPENDIX C – Sphere Benchmark Test

## *Sphere Geometry Input File*

```
20 24
.0 .0 -.2
.0 .0 .2
7.51539E-02 4.33901E-02 -.180192
.135417 7.81831E-02 -.124698
.1688612 9.74921E-02 -4.45101E-02
.1688612 9.74921E-02 4.45101E-02
.135417 7.81831E-02 .1246981
7.51539E-02 4.33901E-02 .1801921
7.51539E-02 -4.33901E-02 .1801921
.135417 -7.81831E-02 .1246981
.1688612 -9.74921E-02 4.45101E-02
.1688612 -9.74921E-02 -4.45101E-02
.135417 -7.81831E-02 -.124698
7.51539E-02 -4.33901E-02 -.180192
.1887247 -4.30903E-02 5.02613E-02
.192097 2.21275E-02 5.10791E-02
.1458002 -3.07120E-03 .136868
.1887021 4.30898E-02 -5.03463E-02
.1920753 -2.21279E-02 -5.11608E-02
.1457827 3.07106E-03 -.136887
43
14
3 14
8 9
3 20
4 20
14 20
4 18
5 18
18 20
18 19
19 20
6 18
6 16
7 16
16 18
7 17
8 17
16 17
9 17
10 17
10 15
11 15
15 17
15 16
12 15
12 19
13 19
15 19
13 20
16 19
1 14
1 3
2 8
2 9
3 4
4 5
5 6
6 7
7 8
9 10
10 11
11 12
12 13
13 14
```



30 31 1  
32 33 2  
3 34 4  
1 3 5  
6 35 7  
8 9 10  
6 8 4  
7 36 11  
12 37 13  
12 14 11  
15 38 16  
17 13 15  
16 2 18  
18 39 19  
20 40 21  
22 23 17  
20 22 19  
21 41 24  
25 42 26  
27 24 25  
28 43 5  
10 26 28  
29 23 27  
14 29 9

*Incident Angle File*

182  
0 0 0 0 0  
0 0 0 2 0  
0 0 0 4 0  
0 0 0 6 0  
0 0 0 8 0  
0 0 0 10 0  
0 0 0 12 0  
0 0 0 14 0  
0 0 0 16 0  
0 0 0 18 0  
0 0 0 20 0  
0 0 0 22 0  
0 0 0 24 0  
0 0 0 26 0  
0 0 0 28 0  
0 0 0 30 0  
0 0 0 32 0  
0 0 0 34 0  
0 0 0 36 0  
0 0 0 38 0  
0 0 0 40 0  
0 0 0 42 0  
0 0 0 44 0  
0 0 0 46 0  
0 0 0 48 0  
0 0 0 50 0  
0 0 0 52 0  
0 0 0 54 0  
0 0 0 56 0  
0 0 0 58 0  
0 0 0 60 0  
0 0 0 62 0  
0 0 0 64 0  
0 0 0 66 0  
0 0 0 68 0  
0 0 0 70 0  
0 0 0 72 0  
0 0 0 74 0  
0 0 0 76 0  
0 0 0 78 0  
0 0 0 80 0  
0 0 0 82 0  
0 0 0 84 0

0 0 0 86 0  
0 0 0 88 0  
0 0 0 90 0  
0 0 0 92 0  
0 0 0 94 0  
0 0 0 96 0  
0 0 0 98 0  
0 0 0 100 0  
0 0 0 102 0  
0 0 0 104 0  
0 0 0 106 0  
0 0 0 108 0  
0 0 0 110 0  
0 0 0 112 0  
0 0 0 114 0  
0 0 0 116 0  
0 0 0 118 0  
0 0 0 120 0  
0 0 0 122 0  
0 0 0 124 0  
0 0 0 126 0  
0 0 0 128 0  
0 0 0 130 0  
0 0 0 132 0  
0 0 0 134 0  
0 0 0 136 0  
0 0 0 138 0  
0 0 0 140 0  
0 0 0 142 0  
0 0 0 144 0  
0 0 0 146 0  
0 0 0 148 0  
0 0 0 150 0  
0 0 0 152 0  
0 0 0 154 0  
0 0 0 156 0  
0 0 0 158 0  
0 0 0 160 0  
0 0 0 162 0  
0 0 0 164 0  
0 0 0 166 0  
0 0 0 168 0  
0 0 0 170 0  
0 0 0 172 0  
0 0 0 174 0  
0 0 0 176 0  
0 0 0 178 0  
0 0 0 180 0  
0 0 90 0 0  
0 0 90 2 0  
0 0 90 4 0  
0 0 90 6 0  
0 0 90 8 0  
0 0 90 10 0  
0 0 90 12 0  
0 0 90 14 0  
0 0 90 16 0  
0 0 90 18 0  
0 0 90 20 0  
0 0 90 22 0  
0 0 90 24 0  
0 0 90 26 0  
0 0 90 28 0  
0 0 90 30 0  
0 0 90 32 0  
0 0 90 34 0  
0 0 90 36 0  
0 0 90 38 0  
0 0 90 40 0  
0 0 90 42 0  
0 0 90 44 0

0 0 90 46 0  
0 0 90 48 0  
0 0 90 50 0  
0 0 90 52 0  
0 0 90 54 0  
0 0 90 56 0  
0 0 90 58 0  
0 0 90 60 0  
0 0 90 62 0  
0 0 90 64 0  
0 0 90 66 0  
0 0 90 68 0  
0 0 90 70 0  
0 0 90 72 0  
0 0 90 74 0  
0 0 90 76 0  
0 0 90 78 0  
0 0 90 80 0  
0 0 90 82 0  
0 0 90 84 0  
0 0 90 86 0  
0 0 90 88 0  
0 0 90 90 0  
0 0 90 92 0  
0 0 90 94 0  
0 0 90 96 0  
0 0 90 98 0  
0 0 90 100 0  
0 0 90 102 0  
0 0 90 104 0  
0 0 90 106 0  
0 0 90 108 0  
0 0 90 110 0  
0 0 90 112 0  
0 0 90 114 0  
0 0 90 116 0  
0 0 90 118 0  
0 0 90 120 0  
0 0 90 122 0  
0 0 90 124 0  
0 0 90 126 0  
0 0 90 128 0  
0 0 90 130 0  
0 0 90 132 0  
0 0 90 134 0  
0 0 90 136 0  
0 0 90 138 0  
0 0 90 140 0  
0 0 90 142 0  
0 0 90 144 0  
0 0 90 146 0  
0 0 90 148 0  
0 0 90 150 0  
0 0 90 152 0  
0 0 90 154 0  
0 0 90 156 0  
0 0 90 158 0  
0 0 90 160 0  
0 0 90 162 0  
0 0 90 164 0  
0 0 90 166 0  
0 0 90 168 0  
0 0 90 170 0  
0 0 90 172 0  
0 0 90 174 0  
0 0 90 176 0  
0 0 90 178 0  
0 0 90 180 0

**MoM Results**

0.0	0.0	0.0	0.0	0.0	0.15009302E+00	-0.80509044E-01	-0.60800312E-05	-0.15207731E-04
0.0	0.0	0.0	2.0	0.0	0.15009625E+00	-0.80448486E-01	-0.61697683E-05	-0.15299649E-04
0.0	0.0	0.0	4.0	0.0	0.15010616E+00	-0.80266759E-01	-0.63194075E-05	-0.15543221E-04
0.0	0.0	0.0	6.0	0.0	0.15012214E+00	-0.79964243E-01	-0.66653088E-05	-0.16026990E-04
0.0	0.0	0.0	8.0	0.0	0.15014295E+00	-0.79540893E-01	-0.71325067E-05	-0.16735234E-04
0.0	0.0	0.0	10.0	0.0	0.15016745E+00	-0.78997299E-01	-0.77373388E-05	-0.17541854E-04
0.0	0.0	0.0	12.0	0.0	0.15019339E+00	-0.78333929E-01	-0.84328958E-05	-0.18594550E-04
0.0	0.0	0.0	14.0	0.0	0.15021873E+00	-0.77551179E-01	-0.93031513E-05	-0.19780764E-04
0.0	0.0	0.0	16.0	0.0	0.15024106E+00	-0.76649904E-01	-0.10287329E-04	-0.21300826E-04
0.0	0.0	0.0	18.0	0.0	0.15025724E+00	-0.75630695E-01	-0.11353804E-04	-0.22823817E-04
0.0	0.0	0.0	20.0	0.0	0.15026397E+00	-0.74494675E-01	-0.12570266E-04	-0.24679732E-04
0.0	0.0	0.0	22.0	0.0	0.15025748E+00	-0.73242612E-01	-0.13924107E-04	-0.26702786E-04
0.0	0.0	0.0	24.0	0.0	0.15023391E+00	-0.71875796E-01	-0.15311298E-04	-0.28961776E-04
0.0	0.0	0.0	26.0	0.0	0.15018900E+00	-0.70395373E-01	-0.16869593E-04	-0.31371117E-04
0.0	0.0	0.0	28.0	0.0	0.15011816E+00	-0.68802528E-01	-0.18509214E-04	-0.34001867E-04
0.0	0.0	0.0	30.0	0.0	0.15001616E+00	-0.67098923E-01	-0.20297737E-04	-0.36832687E-04
0.0	0.0	0.0	32.0	0.0	0.14987849E+00	-0.65285876E-01	-0.22148166E-04	-0.39948718E-04
0.0	0.0	0.0	34.0	0.0	0.14969943E+00	-0.63365214E-01	-0.24052431E-04	-0.43146691E-04
0.0	0.0	0.0	36.0	0.0	0.14947370E+00	-0.61338596E-01	-0.26083668E-04	-0.46622819E-04
0.0	0.0	0.0	38.0	0.0	0.14919546E+00	-0.59207987E-01	-0.28178991E-04	-0.50214301E-04
0.0	0.0	0.0	40.0	0.0	0.14885890E+00	-0.56975193E-01	-0.30340447E-04	-0.54071072E-04
0.0	0.0	0.0	42.0	0.0	0.14845809E+00	-0.54642491E-01	-0.32579850E-04	-0.58161586E-04
0.0	0.0	0.0	44.0	0.0	0.14798722E+00	-0.52212037E-01	-0.34921573E-04	-0.62326042E-04
0.0	0.0	0.0	46.0	0.0	0.14743999E+00	-0.49686175E-01	-0.37291775E-04	-0.66775501E-04
0.0	0.0	0.0	48.0	0.0	0.14681062E+00	-0.47067340E-01	-0.39791674E-04	-0.71394003E-04
0.0	0.0	0.0	50.0	0.0	0.14609277E+00	-0.44358082E-01	-0.42314983E-04	-0.76062563E-04
0.0	0.0	0.0	52.0	0.0	0.14528061E+00	-0.41561142E-01	-0.44891392E-04	-0.81049759E-04
0.0	0.0	0.0	54.0	0.0	0.14436822E+00	-0.38679220E-01	-0.47553996E-04	-0.86201711E-04
0.0	0.0	0.0	56.0	0.0	0.14334978E+00	-0.35715289E-01	-0.50191535E-04	-0.91520873E-04
0.0	0.0	0.0	58.0	0.0	0.14221975E+00	-0.32672334E-01	-0.52927830E-04	-0.96956508E-04
0.0	0.0	0.0	60.0	0.0	0.14097282E+00	-0.29553501E-01	-0.55779132E-04	-0.10246158E-03
0.0	0.0	0.0	62.0	0.0	0.13960369E+00	-0.26362134E-01	-0.58628393E-04	-0.10826582E-03
0.0	0.0	0.0	64.0	0.0	0.13810755E+00	-0.23101386E-01	-0.61607170E-04	-0.11407641E-03
0.0	0.0	0.0	66.0	0.0	0.13647982E+00	-0.19774918E-01	-0.64591979E-04	-0.12000924E-03
0.0	0.0	0.0	68.0	0.0	0.13471626E+00	-0.16386231E-01	-0.67659399E-04	-0.12601080E-03
0.0	0.0	0.0	70.0	0.0	0.13281305E+00	-0.12938984E-01	-0.70759612E-04	-0.13221121E-03
0.0	0.0	0.0	72.0	0.0	0.13076672E+00	-0.94370628E-02	-0.73940981E-04	-0.13842543E-03
0.0	0.0	0.0	74.0	0.0	0.12857442E+00	-0.58842362E-02	-0.77264689E-04	-0.14465419E-03
0.0	0.0	0.0	76.0	0.0	0.12623371E+00	-0.22845664E-02	-0.80611579E-04	-0.15104086E-03
0.0	0.0	0.0	78.0	0.0	0.12374265E+00	0.13578566E-02	-0.84000851E-04	-0.15746144E-03
0.0	0.0	0.0	80.0	0.0	0.12109978E+00	0.50388626E-02	-0.87528533E-04	-0.16397766E-03
0.0	0.0	0.0	82.0	0.0	0.11830437E+00	0.87541807E-02	-0.91092305E-04	-0.17038074E-03
0.0	0.0	0.0	84.0	0.0	0.11535624E+00	0.12499506E-01	-0.94832416E-04	-0.17703176E-03
0.0	0.0	0.0	86.0	0.0	0.11225589E+00	0.16270345E-01	-0.98573808E-04	-0.18352570E-03
0.0	0.0	0.0	88.0	0.0	0.10900422E+00	0.20062268E-01	-0.10247600E-03	-0.19007426E-03
0.0	0.0	0.0	90.0	0.0	0.10560340E+00	0.23870615E-01	-0.10651159E-03	-0.19660831E-03
0.0	0.0	0.0	92.0	0.0	0.10205555E+00	0.27690792E-01	-0.11064012E-03	-0.20311898E-03
0.0	0.0	0.0	94.0	0.0	0.98364174E-01	0.31518143E-01	-0.11483166E-03	-0.20953492E-03
0.0	0.0	0.0	96.0	0.0	0.94532676E-01	0.35347898E-01	-0.11916572E-03	-0.21604172E-03
0.0	0.0	0.0	98.0	0.0	0.90566166E-01	0.39175205E-01	-0.12362651E-03	-0.22241975E-03
0.0	0.0	0.0	100.0	0.0	0.86470172E-01	0.42995308E-01	-0.12814948E-03	-0.22878387E-03
0.0	0.0	0.0	102.0	0.0	0.82250185E-01	0.46803318E-01	-0.13286388E-03	-0.23506607E-03
0.0	0.0	0.0	104.0	0.0	0.77913202E-01	0.50594315E-01	-0.13762884E-03	-0.24125079E-03
0.0	0.0	0.0	106.0	0.0	0.73467016E-01	0.54363534E-01	-0.14252398E-03	-0.24738873E-03
0.0	0.0	0.0	108.0	0.0	0.68919696E-01	0.58105830E-01	-0.14752554E-03	-0.25343389E-03
0.0	0.0	0.0	110.0	0.0	0.64280033E-01	0.61816502E-01	-0.15256410E-03	-0.25937986E-03
0.0	0.0	0.0	112.0	0.0	0.59557602E-01	0.65490521E-01	-0.15777128E-03	-0.26517478E-03
0.0	0.0	0.0	114.0	0.0	0.54762878E-01	0.69122978E-01	-0.16305080E-03	-0.27084499E-03
0.0	0.0	0.0	116.0	0.0	0.49906254E-01	0.72709069E-01	-0.16845817E-03	-0.27643493E-03
0.0	0.0	0.0	118.0	0.0	0.44999447E-01	0.76243930E-01	-0.17385793E-03	-0.28190573E-03
0.0	0.0	0.0	120.0	0.0	0.40054314E-01	0.79722695E-01	-0.17932228E-03	-0.28721659E-03
0.0	0.0	0.0	122.0	0.0	0.35083264E-01	0.83140634E-01	-0.18482754E-03	-0.29236553E-03
0.0	0.0	0.0	124.0	0.0	0.30099165E-01	0.86493120E-01	-0.19036511E-03	-0.29736539E-03
0.0	0.0	0.0	126.0	0.0	0.25115257E-01	0.89775346E-01	-0.19594976E-03	-0.30224034E-03
0.0	0.0	0.0	128.0	0.0	0.20145293E-01	0.92982762E-01	-0.20140028E-03	-0.30695493E-03
0.0	0.0	0.0	130.0	0.0	0.15203021E-01	0.96111141E-01	-0.20695895E-03	-0.31144379E-03
0.0	0.0	0.0	132.0	0.0	0.10302630E-01	0.99155612E-01	-0.21252557E-03	-0.31581789E-03
0.0	0.0	0.0	134.0	0.0	0.54587484E-02	0.10211220E+00	-0.21802736E-03	-0.32000800E-03
0.0	0.0	0.0	136.0	0.0	0.68558636E-03	0.10497674E+00	-0.22339252E-03	-0.32400101E-03

0.0	0.0	0.0	138.0	0.0	-0.40022340E-02	0.10774478E+00	-0.22869477E-03	-0.32782395E-03
0.0	0.0	0.0	140.0	0.0	-0.85902745E-02	0.11041283E+00	-0.23391175E-03	-0.33147036E-03
0.0	0.0	0.0	142.0	0.0	-0.13064067E-01	0.11297665E+00	-0.23896461E-03	-0.33492324E-03
0.0	0.0	0.0	144.0	0.0	-0.17409168E-01	0.11543275E+00	-0.24395893E-03	-0.33819754E-03
0.0	0.0	0.0	146.0	0.0	-0.21611799E-01	0.11777749E+00	-0.24873548E-03	-0.34126689E-03
0.0	0.0	0.0	148.0	0.0	-0.25658069E-01	0.12000714E+00	-0.25345443E-03	-0.34420149E-03
0.0	0.0	0.0	150.0	0.0	-0.29534541E-01	0.12211896E+00	-0.25786075E-03	-0.34687590E-03
0.0	0.0	0.0	152.0	0.0	-0.33228118E-01	0.12410948E+00	-0.26217915E-03	-0.34940740E-03
0.0	0.0	0.0	154.0	0.0	-0.36726441E-01	0.12597600E+00	-0.26614626E-03	-0.35176202E-03
0.0	0.0	0.0	156.0	0.0	-0.40017512E-01	0.12771565E+00	-0.27003072E-03	-0.35391771E-03
0.0	0.0	0.0	158.0	0.0	-0.43089807E-01	0.12932582E+00	-0.27347103E-03	-0.35586781E-03
0.0	0.0	0.0	160.0	0.0	-0.45932937E-01	0.13080411E+00	-0.27685185E-03	-0.35765700E-03
0.0	0.0	0.0	162.0	0.0	-0.48536677E-01	0.13214855E+00	-0.27981642E-03	-0.35929482E-03
0.0	0.0	0.0	164.0	0.0	-0.50891966E-01	0.13335681E+00	-0.28257089E-03	-0.36070609E-03
0.0	0.0	0.0	166.0	0.0	-0.52990522E-01	0.13442717E+00	-0.28495124E-03	-0.36195153E-03
0.0	0.0	0.0	168.0	0.0	-0.54824654E-01	0.13535830E+00	-0.28711403E-03	-0.36306866E-03
0.0	0.0	0.0	170.0	0.0	-0.56387987E-01	0.13614835E+00	-0.28886192E-03	-0.36396118E-03
0.0	0.0	0.0	172.0	0.0	-0.57674885E-01	0.13679650E+00	-0.29041606E-03	-0.36471721E-03
0.0	0.0	0.0	174.0	0.0	-0.58680616E-01	0.13730156E+00	-0.29155440E-03	-0.36530729E-03
0.0	0.0	0.0	176.0	0.0	-0.59401643E-01	0.13766293E+00	-0.29239632E-03	-0.36569647E-03
0.0	0.0	0.0	178.0	0.0	-0.59835255E-01	0.13787994E+00	-0.29295660E-03	-0.36595785E-03
0.0	0.0	0.0	180.0	0.0	-0.59980057E-01	0.13795224E+00	-0.29314251E-03	-0.36604155E-03
0.0	0.0	90.0	0.0	0.0	0.60466455E-05	0.15138236E-04	0.15009287E+00	-0.80508985E-01
0.0	0.0	90.0	2.0	0.0	0.62427675E-05	0.15631893E-04	0.15009885E+00	-0.80524817E-01
0.0	0.0	90.0	4.0	0.0	0.67991664E-05	0.16976090E-04	0.15011699E+00	-0.80572039E-01
0.0	0.0	90.0	6.0	0.0	0.77420264E-05	0.19149298E-04	0.15014669E+00	-0.80650799E-01
0.0	0.0	90.0	8.0	0.0	0.90444209E-05	0.22177333E-04	0.15018760E+00	-0.80760933E-01
0.0	0.0	90.0	10.0	0.0	0.10698802E-04	0.26121481E-04	0.15023915E+00	-0.80902375E-01
0.0	0.0	90.0	12.0	0.0	0.12693113E-04	0.30858995E-04	0.15030037E+00	-0.81075050E-01
0.0	0.0	90.0	14.0	0.0	0.14995376E-04	0.36252928E-04	0.15037018E+00	-0.81278853E-01
0.0	0.0	90.0	16.0	0.0	0.17578413E-04	0.42481348E-04	0.15044744E+00	-0.81513591E-01
0.0	0.0	90.0	18.0	0.0	0.20441061E-04	0.49357943E-04	0.15053084E+00	-0.81779100E-01
0.0	0.0	90.0	20.0	0.0	0.23570570E-04	0.56755824E-04	0.15061855E+00	-0.82075089E-01
0.0	0.0	90.0	22.0	0.0	0.26861644E-04	0.64752057E-04	0.15070911E+00	-0.82401410E-01
0.0	0.0	90.0	24.0	0.0	0.30362233E-04	0.73181538E-04	0.15080024E+00	-0.82757808E-01
0.0	0.0	90.0	26.0	0.0	0.34030942E-04	0.82080944E-04	0.15089038E+00	-0.83143912E-01
0.0	0.0	90.0	28.0	0.0	0.37869351E-04	0.91310394E-04	0.15097697E+00	-0.83559588E-01
0.0	0.0	90.0	30.0	0.0	0.41731022E-04	0.10074665E-03	0.15105772E+00	-0.84004231E-01
0.0	0.0	90.0	32.0	0.0	0.45702447E-04	0.11044172E-03	0.15113017E+00	-0.84477678E-01
0.0	0.0	90.0	34.0	0.0	0.49645543E-04	0.12019265E-03	0.15119170E+00	-0.84979542E-01
0.0	0.0	90.0	36.0	0.0	0.53628293E-04	0.13009099E-03	0.15123956E+00	-0.85509270E-01
0.0	0.0	90.0	38.0	0.0	0.57574016E-04	0.13993745E-03	0.15127084E+00	-0.86066432E-01
0.0	0.0	90.0	40.0	0.0	0.61409548E-04	0.14963943E-03	0.15128261E+00	-0.86650573E-01
0.0	0.0	90.0	42.0	0.0	0.65190616E-04	0.15919696E-03	0.15127222E+00	-0.87261267E-01
0.0	0.0	90.0	44.0	0.0	0.68818052E-04	0.16843832E-03	0.15123609E+00	-0.87897673E-01
0.0	0.0	90.0	46.0	0.0	0.72285744E-04	0.17746411E-03	0.15117136E+00	-0.88559397E-01
0.0	0.0	90.0	48.0	0.0	0.75608055E-04	0.18608797E-03	0.15107468E+00	-0.89245893E-01
0.0	0.0	90.0	50.0	0.0	0.78681034E-04	0.19427255E-03	0.15094315E+00	-0.89956269E-01
0.0	0.0	90.0	52.0	0.0	0.81555496E-04	0.20191268E-03	0.15077339E+00	-0.90690099E-01
0.0	0.0	90.0	54.0	0.0	0.84147374E-04	0.20906805E-03	0.15056224E+00	-0.91446437E-01
0.0	0.0	90.0	56.0	0.0	0.86495085E-04	0.21558734E-03	0.15030615E+00	-0.92224658E-01
0.0	0.0	90.0	58.0	0.0	0.88541674E-04	0.22145973E-03	0.15000258E+00	-0.93024023E-01
0.0	0.0	90.0	60.0	0.0	0.90273403E-04	0.22658851E-03	0.14964801E+00	-0.93843512E-01
0.0	0.0	90.0	62.0	0.0	0.91696362E-04	0.23104838E-03	0.14923970E+00	-0.94682455E-01
0.0	0.0	90.0	64.0	0.0	0.92739057E-04	0.23463959E-03	0.14877455E+00	-0.95539913E-01
0.0	0.0	90.0	66.0	0.0	0.93460621E-04	0.23744068E-03	0.14824998E+00	-0.96414916E-01
0.0	0.0	90.0	68.0	0.0	0.93791830E-04	0.23941262E-03	0.14766307E+00	-0.97306557E-01
0.0	0.0	90.0	70.0	0.0	0.93759401E-04	0.24047674E-03	0.14701165E+00	-0.98213866E-01
0.0	0.0	90.0	72.0	0.0	0.93347524E-04	0.24062009E-03	0.14629310E+00	-0.99135712E-01
0.0	0.0	90.0	74.0	0.0	0.92528848E-04	0.23983055E-03	0.14550541E+00	-0.10007127E+00
0.0	0.0	90.0	76.0	0.0	0.91312191E-04	0.23814397E-03	0.14464685E+00	-0.10101932E+00
0.0	0.0	90.0	78.0	0.0	0.89678440E-04	0.23550919E-03	0.14371577E+00	-0.10197872E+00
0.0	0.0	90.0	80.0	0.0	0.87599255E-04	0.23183272E-03	0.14271039E+00	-0.10294843E+00
0.0	0.0	90.0	82.0	0.0	0.85143947E-04	0.22727542E-03	0.14162984E+00	-0.10392734E+00
0.0	0.0	90.0	84.0	0.0	0.82249782E-04	0.22174181E-03	0.14047328E+00	-0.10491423E+00
0.0	0.0	90.0	86.0	0.0	0.78923440E-04	0.21520469E-03	0.13924022E+00	-0.10590795E+00
0.0	0.0	90.0	88.0	0.0	0.75171949E-04	0.20786641E-03	0.13793020E+00	-0.10690726E+00
0.0	0.0	90.0	90.0	0.0	0.70989947E-04	0.19951185E-03	0.13654353E+00	-0.10791086E+00
0.0	0.0	90.0	92.0	0.0	0.66373388E-04	0.19023618E-03	0.13508074E+00	-0.10891765E+00
0.0	0.0	90.0	94.0	0.0	0.61316176E-04	0.18003548E-03	0.13354240E+00	-0.10992634E+00
0.0	0.0	90.0	96.0	0.0	0.55846609E-04	0.16905337E-03	0.13193025E+00	-0.11093566E+00

0.0	0.0	90.0	98.0	0.0	0.49927196E-04	0.15724938E-03	0.13024539E+00	-0.11194427E+00
0.0	0.0	90.0	100.0	0.0	0.43609263E-04	0.14461954E-03	0.12848999E+00	-0.11295079E+00
0.0	0.0	90.0	102.0	0.0	0.36856149E-04	0.13133597E-03	0.12666644E+00	-0.11395434E+00
0.0	0.0	90.0	104.0	0.0	0.29690220E-04	0.11721549E-03	0.12477736E+00	-0.11495316E+00
0.0	0.0	90.0	106.0	0.0	0.22136637E-04	0.10249738E-03	0.12282605E+00	-0.11594605E+00
0.0	0.0	90.0	108.0	0.0	0.14196537E-04	0.87243970E-04	0.12081626E+00	-0.11693198E+00
0.0	0.0	90.0	110.0	0.0	0.58613368E-05	0.71410053E-04	0.11875167E+00	-0.11790952E+00
0.0	0.0	90.0	112.0	0.0	-0.28482166E-05	0.55089433E-04	0.11663664E+00	-0.11887726E+00
0.0	0.0	90.0	114.0	0.0	-0.11910713E-04	0.38329275E-04	0.11447591E+00	-0.11983395E+00
0.0	0.0	90.0	116.0	0.0	-0.21311118E-04	0.21250980E-04	0.11227451E+00	-0.12077837E+00
0.0	0.0	90.0	118.0	0.0	-0.31056788E-04	0.38118778E-05	0.11003793E+00	-0.12170897E+00
0.0	0.0	90.0	120.0	0.0	-0.41050058E-04	-0.13786974E-04	0.10777183E+00	-0.12262511E+00
0.0	0.0	90.0	122.0	0.0	-0.51371069E-04	-0.31584917E-04	0.10548232E+00	-0.12352496E+00
0.0	0.0	90.0	124.0	0.0	-0.61904175E-04	-0.49473121E-04	0.10317564E+00	-0.12440755E+00
0.0	0.0	90.0	126.0	0.0	-0.72718860E-04	-0.67453700E-04	0.10085848E+00	-0.12527162E+00
0.0	0.0	90.0	128.0	0.0	-0.83625811E-04	-0.85363114E-04	0.98537542E-01	-0.12611592E+00
0.0	0.0	90.0	130.0	0.0	-0.94805015E-04	-0.10315383E-03	0.96219979E-01	-0.12693945E+00
0.0	0.0	90.0	132.0	0.0	-0.10601763E-03	-0.12077698E-03	0.93912855E-01	-0.12774055E+00
0.0	0.0	90.0	134.0	0.0	-0.11740291E-03	-0.13812412E-03	0.91623724E-01	-0.12851885E+00
0.0	0.0	90.0	136.0	0.0	-0.12878262E-03	-0.15531036E-03	0.89359917E-01	-0.12927283E+00
0.0	0.0	90.0	138.0	0.0	-0.14017153E-03	-0.17207037E-03	0.87128997E-01	-0.13000120E+00
0.0	0.0	90.0	140.0	0.0	-0.15154250E-03	-0.18839352E-03	0.84938549E-01	-0.13070348E+00
0.0	0.0	90.0	142.0	0.0	-0.16281912E-03	-0.20431851E-03	0.82796134E-01	-0.13137825E+00
0.0	0.0	90.0	144.0	0.0	-0.17393783E-03	-0.21965563E-03	0.80709249E-01	-0.13202450E+00
0.0	0.0	90.0	146.0	0.0	-0.18488229E-03	-0.23447812E-03	0.78685425E-01	-0.13264169E+00
0.0	0.0	90.0	148.0	0.0	-0.19550895E-03	-0.24868050E-03	0.76731898E-01	-0.13322861E+00
0.0	0.0	90.0	150.0	0.0	-0.20599308E-03	-0.26227138E-03	0.74855939E-01	-0.13378423E+00
0.0	0.0	90.0	152.0	0.0	-0.21594731E-03	-0.27508236E-03	0.73064417E-01	-0.13430835E+00
0.0	0.0	90.0	154.0	0.0	-0.22565035E-03	-0.28715638E-03	0.71364202E-01	-0.13479958E+00
0.0	0.0	90.0	156.0	0.0	-0.23484563E-03	-0.29851092E-03	0.69761552E-01	-0.13525757E+00
0.0	0.0	90.0	158.0	0.0	-0.24358882E-03	-0.30900943E-03	0.68262801E-01	-0.13568126E+00
0.0	0.0	90.0	160.0	0.0	-0.25163734E-03	-0.31871995E-03	0.66873729E-01	-0.13607045E+00
0.0	0.0	90.0	162.0	0.0	-0.25923402E-03	-0.32761757E-03	0.65599695E-01	-0.13642430E+00
0.0	0.0	90.0	164.0	0.0	-0.26606608E-03	-0.33556332E-03	0.64445749E-01	-0.13674241E+00
0.0	0.0	90.0	166.0	0.0	-0.27222765E-03	-0.34265500E-03	0.63416347E-01	-0.13702412E+00
0.0	0.0	90.0	168.0	0.0	-0.27766547E-03	-0.34882536E-03	0.62515773E-01	-0.13726933E+00
0.0	0.0	90.0	170.0	0.0	-0.28227599E-03	-0.35406186E-03	0.61747495E-01	-0.13747728E+00
0.0	0.0	90.0	172.0	0.0	-0.28613606E-03	-0.35839539E-03	0.61114680E-01	-0.13764793E+00
0.0	0.0	90.0	174.0	0.0	-0.28922639E-03	-0.36174746E-03	0.60619745E-01	-0.13778093E+00
0.0	0.0	90.0	176.0	0.0	-0.29139966E-03	-0.36415618E-03	0.60264800E-01	-0.13787599E+00
0.0	0.0	90.0	178.0	0.0	-0.29264533E-03	-0.36556256E-03	0.60051326E-01	-0.13793312E+00
0.0	0.0	90.0	180.0	0.0	-0.29313006E-03	-0.36607002E-03	0.59979990E-01	-0.13795228E+00