

1981/20. Programs for calculation of the gravitational and magnetic anomaly of 3-dimensional bodies

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Abstract

The gravitational and magnetic anomalies of three dimensional bodies specified by structure contours may be readily calculated allowing comprehensive quantitative interpretation of most geological structures.

INTRODUCTION

When quantitatively interpreting gravity and magnetic surveys modelling is frequently performed by assuming structures are two-dimensional and correcting for end effects, or by approximating the structure with a series of three-dimensional bodies with simple geometry, for which individual anomalies can be easily calculated. These methods become very tedious and may be inaccurate. An alternative method formulated by Talwani and Ewing (1960) and Talwani (1965) calculates the anomaly caused by irregular horizontal polygonal laminae and allows bodies to be of any complexity. Commonly the model may consist only of structure contours, and provided the model can be visualised and digitised, the anomaly may be calculated.

The three programs presented here (Appendices 3, 4 and 5) implement the Talwani method with several restrictions:

- (i) All bodies must lie below the observation points;
- (ii) There may be a problem if a computation point is above a body vertex;
- (iii) If the uppermost contour is not far enough below the lowest computing point, or if the contour vertices are very close together (depending on the horizontal and vertical units), spurious anomalies may result.

The programs were originally written in ALGOL for an Elliott 503 by the New Zealand Department of Scientific and Industrial Research.

DATA INPUT AND OUTPUT

The three programs share common input and output formats but, only U1776 actually makes use of the magnetic data.

Input data (Appendix 1) is read from File 5 and is:

TITLE - a maximum of 81 characters. The first character is ignored.

UH1, UV1, AZ - format (2I2, F4.1)
- the horizontal units, vertical units, and azimuth in degrees.

The unit code is

- 0 metres
- 1 feet
- 2 yards
- 3 fathoms
- 4 kilometres
- 5 statute miles
- 6 nautical miles

- PPC(I), A, B, C - format (I4, 3F8.3)
- more than 1 and less than 101 computing points specified by point number with X, Y and Z coordinates.
 - a negative integer for the computing point number terminates this input phase.
 - heights are positive above the datum.

- NCO - format (I2)
- the number of sets of constants following. $NCO \leq 10$.
 - this allows the anomalies from one body and several sets of constants to be calculated.
 - the final set of constants is used for any cumulative results.
 - the program run is terminated by $NCO < 0$.

- DENS, SUSC, FNI, DNI, IN, FR, DR, IR
- format (F6.3, E10.3, F8.1, 2F5.1, E10.3, 2F5.1)
 - DENS = density in t/m^3
 - SUSC = susceptibility in e.m.u.
 - FNI = total normal field in gammas
 - DNI = declination of normal field in degrees
 - IN = inclination of normal field in degrees
 - FR = total remanent magnetisation in e.m.u.
 - DR = declination of remanent magnetisation in degrees
 - IR = inclination of remanent magnetisation in degrees

- NC - format (I3)
- an odd positive integer equal to the number of body cross-sections (contours) following.
 - $3 \leq NC \leq 15$.

- A, M - format (F8.2, I4)
- the vertical coordinate of the cross section (negative below the datum) and the number of vertices of the cross-section.
 - the cross-sections should be given in order either upward or downward.

- B, C - format (2F8.3)
- M sets of cross-section vertices with northing then easting.
 - the vertices must be given in clockwise order looking down.
 - the total number of vertices for the whole body should be less than 450.
 - the program adds one vertex to close the body back to the first point.

NPROB, NCPT, RPLACE, NCONST

- format (4I2)
- four parameters to control subsequent program flow.
- NPROB.NE.O = next body is to replace all previous bodies
- NCPT.NE.O = a new set of computing points is to be read after this computation in which case a new body is also assumed and replaces all previous bodies. A new TITLE and UH1, UV1, AZ are also read.
- RPLACE.NE.O = the next body replaces the last body read.
- RPLACE.EQ.O = the next body is to be added to the previous body in which case the last set of constants will be used for the accumulation.
- NCONST.NE.O = new constants are to be read in.
 - to stop the program NCONST = 1 and NCO.LE.O.

Output data (Appendix 2) on File 6 is:

TITLE

UH1, UV1, AZ

Computing points - Point number, X, Y, Z.

The constants to be used for a particular calculation - magnetic constants are output only from U1776.

The volume, centre of mass, and mass of the body. If there is more than one body a cumulative mass and centre of mass are also output.

The anomaly at each computing point with a value corresponding to each set of constants, in the order input, and the cumulative total (if any) last.

The anomaly types are:

- G - gravity effect of the body (mgals)
- GI - the indirect gravitational effect
- N - the northerly deflection of the vertical
- E - the easterly deflection of the vertical (seconds)
- GZZ - the second vertical gravity derivative
- V - vertical component of the magnetic field anomaly
- H - horizontal component of the magnetic field anomaly
- F - total magnetic force anomaly
- D - declination anomaly

Program U2588 outputs G, GI, N, E, GZZ and program.U2588/SIMPLE outputs only G and GZZ.

A number of the output formats are dynamically set in the following manner:

106 WRITE (6,106) PPC(I), IF1TEM, BH, A, B, IF2TEM, BV, C
106 FORMAT (1X, I6, 2F*.*, F*.)

this has the effect of:

```
WRITE (6,106) PPC(I), A, B, C
106  FORMAT (1X, I6, 2F1F1TEM.BH, F1F2TEM.BV)
```

RUN TIMES

The program run times vary significantly with the model complexity. For the test data (Appendix 1) on a Burroughs B6700, computer times are

<i>Program</i>	<i>Processor time</i>
U1776	52.5 seconds
U2588	51.0 seconds
U2588/SIMPLE	29.2 seconds

The main benefit of U2588 over U1776 is a reduction in storage requirements particularly for large data sets.

REFERENCES

- TALWANI, M.; EWING, M. 1960. Rapid computation of gravitational attraction of three-dimensional bodies of arbitrary shape. *Geophysics* 25:203-225.
- TALWANI, M. 1965. Computation with the help of a digital computer of magnetic anomalies caused by bodies of arbitrary shape. *Geophysics* 30:797-817.

[13 April 1981]

APPENDIX 1: Sample of input

7800	4.9	1.0
7900	5.0	0.0
8000	-7.5	28
8100	4.9	-1.0
8200	4.58	-2.0
8300	4.0	-3.0
8400	3.0	-4.0
8500	2.0	-4.58
8600	1.0	-4.9
8700	0.0	-5.0
8800	-1.0	-4.9
8900	-2.0	-4.58
9000	-3.0	-4.0
9100	-4.0	-3.0
9200	-4.58	-2.0
9300	-4.9	-1.0
9400	-5.0	0.0
9500	-4.9	1.0
9600	-4.58	2.0
9700	-4.0	3.0
9800	-3.0	4.0
9900	-2.0	4.58
10000	-1.0	4.9
10100	0.0	5.0
10200	1.0	4.9
10300	2.0	4.58
10400	3.0	4.0
10500	4.0	3.0
10600	4.58	2.0
10700	4.9	1.0
10800	5.0	0.0
10900	-10.0	28
11000	4.9	-1.0
11100	4.58	-2.0
11200	4.0	-3.0
11300	3.0	-4.0
11400	2.0	-4.58
11500	1.0	-4.9
11600	0.0	-5.0
11700	-1.0	-4.9
11800	-2.0	-4.58
11900	-3.0	-4.0
12000	-4.0	-3.0
12100	-4.58	-2.0
12200	-4.9	-1.0
12300	-5.0	0.0
12400	-4.9	1.0
12500	-4.58	2.0
12600	-4.0	3.0
12700	-3.0	4.0
12800	-2.0	4.58
12900	-1.0	4.9
13000	0.0	5.0
13100	1.0	4.9
13200	2.0	4.58
13300	3.0	4.0
13400	4.0	3.0
13500	4.58	2.0
13600	4.9	1.0
13700	5.0	0.0
13800	0 0 0 1	
13900	1	
14000	1.5	5.0E-3 39800.0 13.0 35.0 0.0E-0 0.0 0.0
14100	3	
14200	-5.0	28
14300	4.9	-1.0
14400	4.58	-2.0
14500	4.0	-3.0
14600	3.0	-4.0
14700	2.0	-4.58
14800	1.0	-4.9
14900	0.0	-5.0
15000	-1.0	-4.9
15100	-2.0	-4.58
15200	-3.0	-4.0
15300	-4.0	-3.0
15400	-4.58	-2.0
15500	-4.9	-1.0
15600	-5.0	0.0
15700	-4.9	1.0

15800	-4.58	2.0
15900	-4.0	3.0
16000	-3.0	4.0
16100	-2.0	4.58
16200	-1.0	4.9
16300	0.0	5.0
16400	1.0	4.9
16500	2.0	4.58
16600	3.0	4.0
16700	4.0	3.0
16800	4.58	2.0
16900	4.9	1.0
17000	5.0	0.0
17100	-7.5	28
17200	4.9	-1.0
17300	4.58	-2.0
17400	4.0	-3.0
17500	3.0	-4.0
17600	2.0	-4.58
17700	1.0	-4.9
17800	0.0	-5.0
17900	-1.0	-4.9
18000	-2.0	-4.58
18100	-3.0	-4.0
18200	-4.0	-3.0
18300	-4.58	-2.0
18400	-4.9	-1.0
18500	-5.0	0.0
18600	-4.9	1.0
18700	-4.58	2.0
18800	-4.0	3.0
18900	-3.0	4.0
19000	-2.0	4.58
19100	-1.0	4.9
19200	0.0	5.0
19300	1.0	4.9
19400	2.0	4.58
19500	3.0	4.0
19600	4.0	3.0
19700	4.58	2.0
19800	4.9	1.0
19900	5.0	0.0
20000	-10.0	28
20100	4.9	-1.0
20200	4.58	-2.0
20300	4.0	-3.0
20400	3.0	-4.0
20500	2.0	-4.58
20600	1.0	-4.9
20700	0.0	-5.0
20800	-1.0	-4.9
20900	-2.0	-4.58
21000	-3.0	-4.0
21100	-4.0	-3.0
21200	-4.58	-2.0
21300	-4.9	-1.0
21400	-5.0	0.0
21500	-4.9	1.0
21600	-4.58	2.0
21700	-4.0	3.0
21800	-3.0	4.0
21900	-2.0	4.58
22000	-1.0	4.9
22100	0.0	5.0
22200	1.0	4.9
22300	2.0	4.58
22400	3.0	4.0
22500	4.0	3.0
22600	4.58	2.0
22700	4.9	1.0
22800	5.0	0.0
22900	0	0
23000	-1	1

APPENDIX 2: Sample of output

D.S.I.R. GEOPHYSICS DIVISION
 THREE-DIMENSIONAL GRAVITY AND MAGNETICS EFFECTS

CYLINDER 14 JAN 74

HORIZONTAL UNITS: 4

VERTICAL UNITS: 4

AZIMUTH: 0. DEGREES

COMPUTING POINTS:

NO	X	Y	Z
1	0.000	10.000	0.000
2	0.000	9.000	0.000
3	0.000	8.000	0.000
4	0.000	7.000	0.000
5	0.000	6.000	0.000
6	0.000	5.001	0.000
7	0.000	4.000	0.000
8	0.000	3.000	0.000
9	0.000	2.000	0.000
10	0.000	1.000	0.000
11	0.000	0.000	0.000
12	0.000	-1.000	0.000
13	0.000	-2.000	0.000
14	0.000	-3.000	0.000
15	0.000	-4.000	0.000
16	0.000	-5.001	0.000
17	0.000	-6.000	0.000
18	0.000	-7.000	0.000
19	0.000	-8.000	0.000
20	0.000	-9.000	0.000
21	0.000	-10.000	0.000
22	-10.000	0.000	0.000
23	-9.000	0.000	0.000
24	-8.000	0.000	0.000
25	-7.000	0.000	0.000
26	-6.000	0.000	0.000
27	-5.001	0.000	0.000
28	-4.000	0.000	0.000
29	-3.000	0.000	0.000
30	-2.000	0.000	0.000
31	-1.000	0.000	0.000
32	0.000	0.000	0.000
33	1.000	0.000	0.000
34	2.000	0.000	0.000
35	3.000	0.000	0.000
36	4.000	0.000	0.000
37	5.001	0.000	0.000
38	6.000	0.000	0.000
39	7.000	0.000	0.000
40	8.000	0.000	0.000
41	9.000	0.000	0.000
42	10.000	0.000	0.000

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CONSTANTS:

DENSITY	SUSCEPTIBILITY	NORMAL FIELD			INCLN		REMANENT MAGNETISATION		
		F (GAMMAS)	DECLN	DECLN			F (EMU)	DECLN	INCLN
0.500	.5000E-02	39800.	13.	35.	0.	0.	0.	0.	
1.000	.5000E-02	39800.	13.	35.	0.	0.	0.	0.	
1.500	.5000E-02	39800.	13.	35.	0.	0.	0.	0.	

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BODY:

Z	NV	X	Y	X	Y	X	Y	X	Y	X	Y
-5.000	28	4.900	-1.000	4.580	-2.000	4.000	-3.000	3.000	-4.000	2.000	-4.580
		1.000	-4.900	0.000	-5.000	-1.000	-4.900	-2.000	-4.580	-3.000	-4.000
		-4.000	-3.000	-4.580	-2.000	-4.900	-1.000	-5.000	0.000	-4.900	1.000
		-4.580	2.000	-4.000	3.000	-3.000	4.000	-2.000	4.580	-1.000	4.900
		0.000	5.000	1.000	4.900	2.000	4.580	3.000	4.000	4.000	3.000
		4.580	2.000	4.900	1.000	5.000	0.000	0.000	0.000	0.000	0.000
-7.500	28	4.900	-1.000	4.580	-2.000	4.000	-3.000	3.000	-4.000	2.000	-4.580
		1.000	-4.900	0.000	-5.000	-1.000	-4.900	-2.000	-4.580	-3.000	-4.000
		-4.000	-3.000	-4.580	-2.000	-4.900	-1.000	-5.000	0.000	-4.900	1.000
		-4.580	2.000	-4.000	3.000	-3.000	4.000	-2.000	4.580	-1.000	4.900
		0.000	5.000	1.000	4.900	2.000	4.580	3.000	4.000	4.000	3.000
		4.580	2.000	4.900	1.000	5.000	0.000	0.000	0.000	0.000	0.000
-10.000	28	4.900	-1.000	4.580	-2.000	4.000	-3.000	3.000	-4.000	2.000	-4.580
		1.000	-4.900	0.000	-5.000	-1.000	-4.900	-2.000	-4.580	-3.000	-4.000
		-4.000	-3.000	-4.580	-2.000	-4.900	-1.000	-5.000	0.000	-4.900	1.000
		-4.580	2.000	-4.000	3.000	-3.000	4.000	-2.000	4.580	-1.000	4.900
		0.000	5.000	1.000	4.900	2.000	4.580	3.000	4.000	4.000	3.000
		4.580	2.000	4.900	1.000	5.000	0.000	0.000	0.000	0.000	0.000

VOLUME = -.3892E+18 C.C.
 DENSITY MASS
 0.500 -.1946E+18

$\bar{x} = 0.000$ $\bar{y} = -0.000$ $\bar{z} = -7.500$

1.000 -.3892E+18
 1.500 -.5838E+18

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COMPTG PT	G	GI	N	E	GZZ	V	H	F	D
1	-5.22	-5.19	-0.	-1.	10.0	-16.	21.	8.	-4.8
	-10.44	-10.38	-0.	-3.	20.1	-16.	21.	8.	-4.8
	-15.66	-15.56	-0.	-4.	30.1	-16.	21.	8.	-4.8
2	-6.31	-6.27	-0.	-1.	9.2	-24.	25.	7.	-5.6
	-12.62	-12.55	-0.	-3.	18.5	-24.	25.	7.	-5.6
	-18.93	-18.82	-0.	-4.	27.7	-24.	25.	7.	-5.6
3	-7.62	-7.59	-0.	-2.	5.5	-35.	31.	5.	-6.4
	-15.25	-15.17	-0.	-3.	11.1	-35.	31.	5.	-6.4
	-22.87	-22.76	-0.	-5.	16.6	-35.	31.	5.	-6.4
4	-9.17	-9.13	-0.	-2.	-3.1	-50.	37.	2.	-7.2
	-18.34	-18.26	-0.	-3.	-6.2	-50.	37.	2.	-7.2
	-27.50	-27.39	-0.	-5.	-9.3	-50.	37.	2.	-7.2
5	-10.91	-10.87	-0.	-2.	-18.6	-69.	45.	-2.	-7.6
	-21.83	-21.74	-0.	-3.	-37.1	-69.	45.	-2.	-7.6
	-32.74	-32.61	-0.	-5.	-55.7	-69.	45.	-2.	-7.6
6	-12.77	-12.73	-0.	-2.	-40.3	-89.	54.	-6.	-7.6
	-25.54	-25.45	-0.	-3.	-80.5	-89.	54.	-6.	-7.6
	-38.31	-38.18	-0.	-5.	-120.8	-89.	54.	-6.	-7.6
7	-14.60	-14.55	-0.	-1.	-64.2	-108.	64.	-9.	-6.9
	-29.20	-29.11	-0.	-3.	-128.4	-108.	64.	-9.	-6.9
	-43.80	-43.66	-0.	-4.	-192.7	-108.	64.	-9.	-6.9
8	-16.23	-16.18	-0.	-1.	-85.0	-124.	74.	-10.	-5.6
	-32.45	-32.36	-0.	-2.	-170.1	-124.	74.	-10.	-5.6
	-48.68	-48.53	-0.	-3.	-255.1	-124.	74.	-10.	-5.6

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COMPTG PT	G	GI	N	E	GZZ	V	H	F	D
9	-17.50	-17.45	-0.	-1.	-99.7	-134.	83.	-8.	-3.9
	-34.99	-34.89	-0.	-2.	-199.4	-134.	83.	-8.	-3.9
	-52.49	-52.34	-0.	-2.	-299.1	-134.	83.	-8.	-3.9
10	-18.30	-18.25	-0.	-0.	-107.9	-137.	90.	-4.	-2.0
	-36.60	-36.50	-0.	-1.	-215.8	-137.	90.	-4.	-2.0
	-54.90	-54.75	-0.	-1.	-323.8	-137.	90.	-4.	-2.0
11	-18.58	-18.53	-0.	-0.	-110.5	-134.	96.	2.	0.0
	-37.15	-37.05	-0.	-0.	-221.1	-134.	96.	2.	0.0
	-55.73	-55.58	-0.	-0.	-331.6	-134.	96.	2.	0.0
12	-18.30	-18.25	-0.	0.	-107.9	-125.	99.	9.	1.9
	-36.60	-36.50	-0.	1.	-215.8	-125.	99.	9.	1.9
	-54.90	-54.75	-0.	1.	-323.8	-125.	99.	9.	1.9
13	-17.50	-17.45	-0.	1.	-99.7	-111.	99.	18.	3.5
	-34.99	-34.89	-0.	2.	-199.4	-111.	99.	18.	3.5
	-52.49	-52.34	-0.	2.	-299.1	-111.	99.	18.	3.5
14	-16.23	-16.18	-0.	1.	-85.0	-91.	97.	27.	4.7
	-32.45	-32.36	-0.	2.	-170.1	-91.	97.	27.	4.7
	-48.68	-48.53	-0.	3.	-255.1	-91.	97.	27.	4.7
15	-14.60	-14.55	-0.	1.	-64.2	-70.	91.	35.	5.4
	-29.20	-29.11	-0.	3.	-128.4	-70.	91.	35.	5.4
	-43.80	-43.66	-0.	4.	-192.7	-70.	91.	35.	5.4
16	-12.77	-12.73	-0.	2.	-40.3	-48.	83.	41.	5.5
	-25.54	-25.45	-0.	3.	-80.5	-48.	83.	41.	5.5
	-38.31	-38.18	-0.	5.	-120.8	-48.	83.	41.	5.5

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CUMPTG PT	G	GI	N	E	GZZ	V	H	F	D
17	-10.91	-10.87	-0.	2.	-18.6	-29.	73.	44.	5.1
	-21.83	-21.74	-0.	3.	-37.1	-29.	73.	44.	5.1
	-32.74	-32.61	-0.	5.	-55.7	-29.	73.	44.	5.1
18	-9.17	-9.13	-0.	2.	-3.1	-14.	63.	43.	4.4
	-18.34	-18.26	-0.	3.	-6.2	-14.	63.	43.	4.4
	-27.50	-27.39	-0.	5.	-9.3	-14.	63.	43.	4.4
19	-7.62	-7.59	-0.	2.	5.5	-4.	53.	41.	3.6
	-15.25	-15.17	-0.	3.	11.1	-4.	53.	41.	3.6
	-22.87	-22.76	-0.	5.	16.6	-4.	53.	41.	3.6
20	-6.31	-6.27	-0.	1.	9.2	3.	44.	37.	2.8
	-12.62	-12.55	-0.	3.	18.5	3.	44.	37.	2.8
	-18.93	-18.82	-0.	4.	27.7	3.	44.	37.	2.8
21	-5.22	-5.19	-0.	1.	10.0	6.	36.	33.	2.2
	-10.44	-10.38	-0.	3.	20.1	6.	36.	33.	2.2
	-15.66	-15.56	-0.	4.	30.1	6.	36.	33.	2.2
22	-5.22	-5.19	1.	0.	10.0	42.	11.	33.	0.5
	-10.44	-10.38	3.	0.	20.1	42.	11.	33.	0.5
	-15.66	-15.56	4.	0.	30.1	42.	11.	33.	0.5
23	-6.31	-6.27	1.	0.	9.2	46.	21.	44.	0.4
	-12.62	-12.55	3.	0.	18.5	46.	21.	44.	0.4
	-18.93	-18.82	4.	0.	27.7	46.	21.	44.	0.4
24	-7.62	-7.59	2.	0.	5.5	49.	34.	56.	0.3
	-15.25	-15.17	3.	0.	11.1	49.	34.	56.	0.3
	-22.87	-22.76	5.	0.	16.6	49.	34.	56.	0.3

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15/49

CUMPIG PT	G	GI	N	E	GZZ	V	H	F	D
25	-9.17	-9.13	2.	-0.	-3.1	47.	51.	69.	0.0
	-18.34	-18.26	3.	-0.	-6.2	47.	51.	69.	0.0
	-27.50	-27.39	5.	-0.	-9.3	47.	51.	69.	0.0
26	-10.91	-10.87	2.	-0.	-18.6	38.	71.	80.	-0.2
	-21.83	-21.74	3.	-0.	-37.1	38.	71.	80.	-0.2
	-32.74	-32.61	5.	-0.	-55.7	38.	71.	80.	-0.2
27	-12.77	-12.73	2.	0.	-40.3	21.	91.	87.	-0.5
	-25.54	-25.45	3.	0.	-80.5	21.	91.	87.	-0.5
	-38.31	-38.18	5.	0.	-120.8	21.	91.	87.	-0.5
28	-14.60	-14.55	1.	0.	-64.2	-5.	108.	85.	-0.7
	-29.20	-29.11	3.	0.	-128.4	-5.	108.	85.	-0.7
	-43.80	-43.66	4.	0.	-192.7	-5.	108.	85.	-0.7
29	-16.23	-16.18	1.	-0.	-85.0	-38.	118.	75.	-0.8
	-32.45	-32.36	2.	-0.	-170.1	-38.	118.	75.	-0.8
	-48.68	-48.53	3.	-0.	-255.1	-38.	118.	75.	-0.8
30	-17.50	-17.45	1.	0.	-99.7	-72.	118.	56.	-0.7
	-34.99	-34.89	2.	0.	-199.4	-72.	118.	56.	-0.7
	-52.49	-52.34	2.	0.	-299.1	-72.	118.	56.	-0.7
31	-18.30	-18.25	0.	-0.	-107.9	-105.	111.	31.	-0.4
	-36.60	-36.50	1.	-0.	-215.8	-105.	111.	31.	-0.4
	-54.90	-54.75	1.	-0.	-323.8	-105.	111.	31.	-0.4
32	-18.58	-18.53	-0.	-0.	-110.5	-134.	96.	2.	0.0
	-37.15	-37.05	-0.	-0.	-221.1	-134.	96.	2.	0.0
	-55.73	-55.58	-0.	-0.	-331.6	-134.	96.	2.	0.0

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15/49

COMPIG PT	G	GI	N	E	GZZ	V	H	F	D
33	-18.30	-18.25	-0.	-0.	-107.9	-157.	74.	-29.	0.5
	-36.60	-36.50	-1.	-0.	-215.8	-157.	74.	-29.	0.5
	-54.90	-54.75	-1.	-0.	-323.6	-157.	74.	-29.	0.5
34	-17.50	-17.45	-1.	-0.	-99.7	-172.	48.	-59.	1.0
	-34.99	-34.89	-2.	-0.	-199.4	-172.	48.	-59.	1.0
	-52.49	-52.34	-2.	-0.	-299.1	-172.	48.	-59.	1.0
35	-16.23	-16.18	-1.	0.	-85.0	-178.	19.	-86.	1.6
	-32.45	-32.36	-2.	0.	-170.1	-178.	19.	-86.	1.6
	-48.68	-48.53	-3.	0.	-255.1	-178.	19.	-86.	1.6
36	-14.60	-14.55	-1.	-0.	-64.2	-173.	-9.	-106.	2.1
	-29.20	-29.11	-3.	-0.	-128.4	-173.	-9.	-106.	2.1
	-43.80	-43.66	-4.	-0.	-192.7	-173.	-9.	-106.	2.1
37	-12.77	-12.73	-2.	-0.	-40.3	-157.	-33.	-117.	2.5
	-25.54	-25.45	-3.	-0.	-80.5	-157.	-33.	-117.	2.5
	-38.31	-38.18	-5.	-0.	-120.8	-157.	-33.	-117.	2.5
38	-10.91	-10.87	-2.	0.	-18.6	-135.	-50.	-119.	2.7
	-21.83	-21.74	-3.	0.	-37.1	-135.	-50.	-119.	2.7
	-32.74	-32.61	-5.	0.	-55.7	-135.	-50.	-119.	2.7
39	-9.17	-9.13	-2.	0.	-3.1	-111.	-59.	-112.	2.7
	-18.34	-18.26	-3.	0.	-6.2	-111.	-59.	-112.	2.7
	-27.50	-27.39	-5.	0.	-9.3	-111.	-59.	-112.	2.7
40	-7.62	-7.59	-2.	0.	5.5	-88.	-62.	-101.	2.6
	-15.25	-15.17	-3.	0.	11.1	-88.	-62.	-101.	2.6
	-22.87	-22.76	-5.	0.	16.6	-88.	-62.	-101.	2.6

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17/49

COMPTG PT	G	GI	N	E	GZZ	V	H	F	D
41	-6.31	-6.27	-1.	0.	9.2	-68.	-59.	-87.	2.4
	-12.62	-12.55	-3.	0.	18.5	-68.	-59.	-87.	2.4
	-18.93	-18.82	-4.	0.	27.7	-68.	-59.	-87.	2.4
42	-5.22	-5.19	-1.	0.	10.0	-52.	-55.	-74.	2.1
	-10.44	-10.38	-3.	0.	20.1	-52.	-55.	-74.	2.1
	-15.66	-15.56	-4.	0.	30.1	-52.	-55.	-74.	2.1

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18/19

CONSTANTS:

DENSITY
1.500

SUSCEPTIBILITY
.5000E-02

NORMAL FIELD
F (GAMMAS) DECLN
39800. 13.

INCLN
35.

REMANENT MAGNETISATION
F (EMU) DECLN INCLN
0. 0. 0.

20-A2/10

19/49

BODY:

Z	NV	X	Y	X	Y	X	Y	X	Y	X	Y
-5.000	28	4.900	-1.000	4.580	-2.000	4.000	-3.000	3.000	-4.000	2.000	-4.580
		1.000	-4.900	0.000	-5.000	-1.000	-4.900	-2.000	-4.580	-3.000	-4.000
		-4.000	-3.000	-4.580	-2.000	-4.900	-1.000	-5.000	0.000	-4.900	1.000
		-4.580	2.000	-4.000	3.000	-3.000	4.000	-2.000	4.580	-1.000	4.900
		0.000	5.000	1.000	4.900	2.000	4.580	3.000	4.000	4.000	3.000
		4.580	2.000	4.900	1.000	5.000	0.000	0.000	0.000	0.000	0.000
-7.500	28	4.900	-1.000	4.580	-2.000	4.000	-3.000	3.000	-4.000	2.000	-4.580
		1.000	-4.900	0.000	-5.000	-1.000	-4.900	-2.000	-4.580	-3.000	-4.000
		-4.000	-3.000	-4.580	-2.000	-4.900	-1.000	-5.000	0.000	-4.900	1.000
		-4.580	2.000	-4.000	3.000	-3.000	4.000	-2.000	4.580	-1.000	4.900
		0.000	5.000	1.000	4.900	2.000	4.580	3.000	4.000	4.000	3.000
		4.580	2.000	4.900	1.000	5.000	0.000	0.000	0.000	0.000	0.000
-10.000	28	4.900	-1.000	4.580	-2.000	4.000	-3.000	3.000	-4.000	2.000	-4.580
		1.000	-4.900	0.000	-5.000	-1.000	-4.900	-2.000	-4.580	-3.000	-4.000
		-4.000	-3.000	-4.580	-2.000	-4.900	-1.000	-5.000	0.000	-4.900	1.000
		-4.580	2.000	-4.000	3.000	-3.000	4.000	-2.000	4.580	-1.000	4.900
		0.000	5.000	1.000	4.900	2.000	4.580	3.000	4.000	4.000	3.000
		4.580	2.000	4.900	1.000	5.000	0.000	0.000	0.000	0.000	0.000

VOLUME = -.3892E+18 C.C.

$\bar{X} = 0.000$ $\bar{Y} = -0.000$ $\bar{Z} = -7.500$

DENSITY MASS
1.500 -.5838E+18

CUMULATIVE: MASS
 $\bar{X} = 0.000$ $\bar{Y} = -0.000$ $\bar{Z} = -7.500$

20-A2/11

20/11

COMPTG PT	G	GI	N	E	GZZ	V	H	F	D
1	-15.66 -31.32	-15.56 -31.13	-0. -0.	-4. -8.	30.1 60.3	-16. -31.	21. 42.	8. 17.	-4.8 -9.5
2	-18.93 -37.86	-18.82 -37.65	-0. -0.	-4. -9.	27.7 55.5	-24. -48.	25. 51.	7. 14.	-5.6 -11.2
3	-22.87 -45.74	-22.76 -45.52	-0. -0.	-5. -9.	16.6 33.3	-35. -70.	31. 61.	5. 10.	-6.4 -12.9
4	-27.50 -55.01	-27.39 -54.77	-0. -0.	-5. -10.	-9.3 -18.7	-50. -100.	37. 75.	2. 4.	-7.2 -14.4
5	-32.74 -65.48	-32.61 -65.23	-0. -0.	-5. -10.	-55.7 -111.3	-69. -137.	45. 90.	-2. -4.	-7.6 -15.3
6	-38.31 -76.62	-38.18 -76.35	-0. -0.	-5. -9.	-120.8 -241.5	-89. -178.	54. 109.	-6. -12.	-7.6 -15.1
7	-43.80 -87.60	-43.66 -87.32	-0. -0.	-4. -8.	-192.7 -385.3	-108. -217.	64. 128.	-9. -18.	-6.9 -13.7
8	-48.68 -97.36	-48.53 -97.07	-0. -0.	-3. -7.	-255.1 -510.3	-124. -248.	74. 148.	-10. -20.	-5.6 -11.2
9	-52.49 -104.98	-52.34 -104.68	-0. -0.	-2. -5.	-299.1 -598.1	-134. -267.	83. 166.	-8. -16.	-3.9 -7.7
10	-54.90 -109.81	-54.75 -109.50	-0. -0.	-1. -2.	-323.8 -647.5	-137. -274.	90. 181.	-4. -8.	-2.0 -3.9
11	-55.73 -111.46	-55.58 -111.15	-0. -0.	-0. -0.	-331.6 -663.2	-134. -268.	96. 191.	2. 4.	0.0 0.0
12	-54.90 -109.81	-54.75 -109.50	-0. -0.	1. 2.	-323.8 -647.5	-125. -250.	99. 197.	9. 20.	1.9 3.7
13	-52.49 -104.98	-52.34 -104.68	-0. -0.	2. 5.	-299.1 -598.1	-111. -221.	99. 198.	18. 37.	3.5 7.0
14	-48.68 -97.36	-48.53 -97.07	-0. -0.	3. 7.	-255.1 -510.3	-91. -183.	97. 193.	27. 54.	4.7 9.4

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2/1/19

COMPTG PT	G	GI	N	E	GZZ	V	H	F	D
15	-43.80 -87.60	-43.66 -87.32	-0. -0.	4. 8.	-192.7 -385.3	-70. -139.	91. 182.	35. 70.	5.4 10.8
16	-38.31 -76.62	-38.18 -76.35	-0. -0.	5. 9.	-120.8 -241.5	-48. -95.	83. 166.	41. 82.	5.5 11.1
17	-32.74 -65.48	-32.61 -65.23	-0. -0.	5. 10.	-55.7 -111.3	-29. -57.	73. 146.	44. 87.	5.1 10.3
18	-27.50 -55.01	-27.39 -54.77	-0. -0.	5. 10.	-9.3 -18.7	-14. -28.	63. 125.	43. 87.	4.4 8.8
19	-22.87 -45.74	-22.76 -45.52	-0. -0.	5. 9.	16.6 33.3	-4. -7.	53. 105.	41. 82.	3.6 7.2
20	-18.93 -37.86	-18.82 -37.65	-0. -0.	4. 9.	27.7 55.5	3. 5.	44. 88.	37. 75.	2.8 5.6
21	-15.66 -31.32	-15.56 -31.13	-0. -0.	4. 8.	30.1 60.3	6. 12.	36. 72.	33. 66.	2.2 4.3
22	-15.66 -31.32	-15.56 -31.13	4. 8.	0. 0.	30.1 60.3	42. 84.	11. 22.	33. 67.	0.5 1.0
23	-18.93 -37.86	-18.82 -37.65	4. 9.	0. 0.	27.7 55.5	46. 93.	21. 41.	44. 87.	0.4 0.8
24	-22.87 -45.74	-22.76 -45.52	5. 9.	0. 0.	16.6 33.3	49. 97.	34. 68.	56. 111.	0.3 0.5
25	-27.50 -55.01	-27.39 -54.77	5. 10.	-0. -0.	-9.3 -18.7	47. 94.	51. 102.	69. 137.	0.0 0.1
26	-32.74 -65.48	-32.61 -65.23	5. 10.	-0. -0.	-55.7 -111.3	38. 76.	71. 142.	80. 160.	-0.2 -0.4
27	-38.31 -76.62	-38.18 -76.35	5. 9.	0. 0.	-120.8 -241.5	21. 42.	91. 183.	87. 174.	-0.5 -1.0
28	-43.80 -87.60	-43.66 -87.32	4. 8.	0. 0.	-192.7 -385.3	-5. -11.	108. 216.	85. 171.	-0.7 -1.4

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22/19

COMPTG PT	G	GI	N	E	GZZ	V	H	F	D
29	-48.68 -97.36	-48.53 -97.07	3. 7.	-0. -0.	-255.1 -510.3	-38. -75.	118. 235.	75. 150.	-0.8 -1.5
30	-52.49 -104.98	-52.34 -104.68	2. 5.	0. 0.	-299.1 -598.1	-72. -144.	118. 237.	56. 112.	-0.7 -1.3
31	-54.90 -109.81	-54.75 -109.51	1. 2.	-0. -0.	-323.8 -647.5	-105. -210.	111. 222.	31. 62.	-0.4 -0.8
32	-55.73 -111.46	-55.58 -111.15	-0. -0.	-0. -0.	-331.6 -663.2	-134. -268.	96. 191.	2. 4.	0.0 0.0
33	-54.90 -109.81	-54.75 -109.50	-1. -2.	-0. -0.	-323.8 -647.5	-157. -314.	74. 149.	-29. -57.	0.5 1.0
34	-52.49 -104.98	-52.34 -104.68	-2. -5.	-0. -0.	-299.1 -598.1	-172. -344.	48. 97.	-59. -117.	1.0 2.1
35	-48.68 -97.36	-48.53 -97.07	-3. -7.	0. 0.	-255.1 -510.3	-178. -355.	19. 39.	-86. -171.	1.6 3.2
36	-43.80 -87.60	-43.66 -87.32	-4. -8.	-0. -0.	-192.7 -385.3	-173. -345.	-9. -18.	-106. -212.	2.1 4.3
37	-38.31 -76.62	-38.18 -76.35	-5. -9.	-0. -0.	-120.8 -241.5	-157. -315.	-33. -67.	-117. -235.	2.5 5.1
38	-32.74 -65.48	-32.61 -65.23	-5. -10.	0. 0.	-55.7 -111.3	-135. -271.	-50. -101.	-119. -237.	2.7 5.5
39	-27.50 -55.01	-27.39 -54.77	-5. -10.	0. 0.	-9.3 -18.7	-111. -221.	-59. -119.	-112. -224.	2.7 5.5
40	-22.87 -45.74	-22.76 -45.52	-5. -9.	0. 0.	16.6 33.3	-88. -175.	-62. -123.	-101. -201.	2.6 5.2
41	-18.93 -37.86	-18.82 -37.65	-4. -9.	0. 0.	27.7 55.5	-68. -135.	-59. -118.	-87. -175.	2.4 4.7
42	-15.66 -31.32	-15.56 -31.13	-4. -8.	0. 0.	30.1 60.3	-52. -103.	-55. -109.	-74. -149.	2.1 4.2

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03/49

APPENDIX 3: Programme FORTRAN/U1776

KFILE: FORTRAN/U1776 (04/06/81)

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100  $SET $
200  $SET LINEINFO
300  $RESET FREE
400  FILE 6(KIND=PRINTER)
500  FILE 5(TITLE="U1776/DATA",KIND=PACK,FILETYPE=7)
600  C U1776 SOLID 3-D ATTRACTION
700  C TRANSLATED FROM THE ALGOL VERSION D.S.I.R. GEOPHYSICS DIVISION.
800  C GPU30 SOLID.
900  C TALWANI METHOD FOR CALCULATING THE GRAVITY AND MAGNETIC EFFECTS
1000 C OF A BODY OF ARBITRARY SHAPE APPROXIMATED BY POLYGONAL CONTOURS
1100 C VIDE TALWANI, EWING, 1959:
1200 C <RAPID COMPUTATION OF GRAVITATIONAL ATTRACTION OF THREE-DIMENSIONAL
1300 C BODIES OF ARBITRARY SHAPE>
1400 C IN GEOPHYSICS, VOL. XXV, NO. 1 (FEBRUARY 1960).
1500 C TALWANI, M., 1964:
1600 C COMPUTATION WITH THE HELP OF A DIGITAL COMPUTER OF MAGNETIC
1700 C ANOMALIES CAUSED BY BODIES OF ARBITRARY SHAPE>
1800 C IN GEOPHYSICS, VOL. XXX, NO. 5 (OCTOBER 1965).
1900 C PROGRAMME WRITTEN BY M.A. SAUNDERS, D.S.I.R. APPLIED MATHEMATICS
2000 C DIVISION, SEPTEMBER 1966 . . . AND ALTERED FOR THE UNIVERSITY OF
2100 C TASMANIA B6700 BY R.G. RICHARDSON (1978 BOTH ALGOL AND FORTRAN).
2200 C LOGICAL NEWPRB, NEWCP, REPLAC, NJCNST, FIRST, NF, NR
2300 C INTEGER I, BUFCNT, IBUF, J, M1, N1, UH1, UV1, NP, NC, ND,
2400 C . NCO, FM, M, AH, BH, AV, PV, NPROB, NCPT,
2500 C . RPLAC, NCONST, CT, YP1, MO, DY1I, NCP, CPC, QA, QB, QC
2600 C REAL UH, UV, XX, YY, ZZ, X1, X2, Y1, Y2, PI,
2700 C . PIBY2, AZ, K, NUMBER, H1, H2, H3, MC, XC, YC, ZC, A, B, C, D, SN, CS
2800 C REAL SCALE(7), V(100), BBUF, CBUF(5), X(100), Y(100), Z(100), DXC,
2900 C . DYC, DZC, GC, GIC, NCU, FCU, GZZC,
3000 C . JX1(10), JY1(10), JZ1(10), XN, YN, ZN, HN, FN,
3100 C . DN, DENS(10), XA(450), YA(450), ZA(15), Q1, Q2, Q3
3200 C INTEGER A1(7), B1(7), PPC(101), TITLE(80), NV(15)
3300 C REAL SUSC, WK, XN1, YN1, ZN1, HN1, FN1, DN1, XR, YR, ZR, IN, FR, DR, IR
3400 C REAL XAA(200), YAA(200), ZAA(200), XL, YL, ZL, ML, CP,
3500 C . SUMX, SUMY, SUMV, V1
3600 C XAA, YAA, ZAA, U, UX, . . . Z3 ARE DIMENSIONED TO LARGEST
3700 C NUMBER OF CONTOURS
3800 C REAL U(100), UX(100), UY(100), UZ(100), U1(100), U2(100), U3(100),
3900 C . U4(100), U5(100), U6(100), Z3(100), UA, UX1, UY1, UZ1, S1, S2, S3, S4,
4000 C . S5, S6, D1, D3, TERM, SUM, Z1, Z2, RX1, RX2, R12, R1, R2, R1I, R2I,
4100 C . EPSLNH, EPSLNV, SQ, CF, DX1, DY1, EN, G1, ENSQ, RT, P, ZPP, FACTOR,
4200 C . IRT, COSG, COSB, BETA, GAMMA, DPSI, DX, DY, DZ, G, GI, N, E, GZZ
4300 C LOGICAL BA, BIG, BB, BC
4400 C REAL JX, PP, Q, W, JY, JZ, NCUTEM, INTEGL
4500 C COMMON /INTGRL/ Q1(7), Q2(7), Q3(7), ND
4600 C COMMON /WKSP/ PP, Q, W, BB, P, PIBY2, DX1, DY1, PI, CF, SQ
4700 C COMMON /FCTDP/ JX, JY, JZ
4800 C COMMON /DLTA/ N1, XN(10), YN(10), ZN(10), BBUF(5),
4900 C . DN(10), HN(10), FN(10), AZ
5000 C COMMON /PLNT/ M1, DXC(100), DYC(100), DZC(100),
5100 C . GIC(100), NCU(100), FCU(100), GC(100), GZZC(100)
5200 C SCALE(5)=1.E5
5300 C SCALE(4)=182.87984
5400 C SCALE(6)=160934.3
5500 C SCALE(1)=1.E2
5600 C SCALE(2)=30.479973
5700 C SCALE(3)=91.4399
5800 C SCALE(7)=185318.2
5900 C K=6.673E-8
6000 C A1(1)=6
6100 C A1(2)=6
6200 C A1(3)=6
6300 C A1(4)=6
6400 C A1(5)=3
6500 C A1(6)=3
6600 C A1(7)=3
6700 C B1(1)=0
6800 C B1(2)=0
6900 C B1(3)=0
7000 C B1(3)=0
7100 C B1(4)=0
7200 C B1(5)=3
7300 C B1(6)=3
7400 C B1(7)=3
7500 C PI=3.1415926536
7600 C PIBY2=PI/2.
7700 C NUMBER=-57.2957795*7600./980.

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7800      NEWPRB=.TRUE.
7900      NEWCP=.TRUE.
8000      NUCNST=.TRUE.
8100      FIRST=.TRUE.
8200      999 CONTINUE
8300      C OLD REPEAT LABEL
8400      IF (.NOT. NEWCP) GO TO 14
8500      C READ COMPUTING POINTS
8600      WRITE(6,100)
8700      100 FORMAT(/37X,"D.S.I.R. GEOPHYSICS DIVISION"/30X,"THREE-DIM F",
8800      . "NSIONAL GRAVITY AND MAGNETICS EFFECTS")
8900      READ(5,101) TITLE
9000      WRITE(6,101) TITLE
9100      101 FORMAT(1X,80A1)
9200      READ(5,102) UH1,UV1,AZ
9300      102 FORMAT(2I2,F4.1)
9400      WRITE(6,103) UH1,UV1,AZ
9500      103 FORMAT(/" HORIZONTAL UNITS:" ,I3,6X,"VERTICAL UNITS:" ,I3,
9600      . 6X,"AZIMUTH:" ,F5.0," DEGREES")
9700      A=AZ*0.017453293
9800      C A=RADIAN(AZ)
9900      SN=SIN(A)
10000     CS=COS(A)
10100     UH1=UH1+1
10200     UV1=UV1+1
10300     AH=A1(UH1)
10400     BH=B1(UH1)
10500     AV=A1(UV1)
10600     BV=B1(UV1)
10700     UH=SCALE(UH1)
10800     UV=SCALE(UV1)
10900     WRITE(6,104)
11000     104 FORMAT(/" COMPUTING POINTS:" /5X,"NO",7X,"X",9X,"Y",9X,"Z")
11100     I=0
11200     NP=0
11300     10 CONTINUE
11400     I=I+1
11500     NP=NP+1
11600     READ(5,105) PPC(I),A,B,C
11700     105 FORMAT(I4,3F8.3)
11800     IF (PPC(I) .LT. 0) GO TO 11
11900     IF1TEM=AH+BH+4
12000     IF2TEM=AV+BV+4
12100     WRITE(6,106) PPC(I),IF1TEM,BH,A,B,IF2TEM,BV,C
12200     106 FORMAT(1X,I6,2F*,*,F*,*)
12300     A=A+1.E-6
12400     X(I)=A*UH
12500     Y(I)=B*UH
12600     Z(I)=-C*UV
12700     GO TO 10
12800     11 I=I-1
12900     NP=NP-1
13000     C END READ COMPUTING POINTS
13100     14 CONTINUE
13200     IF (.NOT. NUCNST) GO TO 16
13300     C READ CONSTANTS
13400     READ(5,107) NCO
13500     107 FORMAT(I2)
13600     IF (NCO .LE. 0) STOP
13700     WRITE(6,108)
13800     108 FORMAT(1H1)
13900     C NEW PAGE
14000     WRITE(6,109)
14100     109 FORMAT(/" CONSTANTS:" /38X,"NORMAL FIELD",18X,"REMANENT ",
14200     . "MAGNETISATION"/6X,"DENSITY SUSCEPTIBILITY F (GAMMAS)",
14300     . " DECLN INCLN",9X,"F (EMJ)",5X,"DECLN INCLN")
14400     DO 15 N1=1,NCO
14500     READ(5,110) DENS(N1),SUSC, FN1, DN1, IN, FR, DR, IR
14600     110 FORMAT(F6.3,E10.3,F8.1,2F5.1,E10.3,2F5.1)
14700     WRITE(6,111) DENS(N1),SUSC, FN1, DN1, IN, FR, DR, IR
14800     111 FORMAT(1X,F11.3,E14.4,F14.0,2F9.0,E17.5,2F9.0)
14900     WK=IN*0.017453293
15000     C WK=RADIAN(IN)
15100     ZN1=FN1*SIN(WK)
15200     HN1=FN1*COS(WK)
15300     WK=(DN1-AZ)*0.017453293
15400     C WK=RADIAN(DN1-AZ)
15500     XN1=HN1*COS(WK)
15600     YN1=HN1*SIN(WK)
15700     FR=FR+1.E5

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15800 WK=IR*0.017453293
15900 C WK=RADIAN(IR)
16000 ZR=FR*SIN(WK)
16100 XR=FR*COS(WK)
16200 WK=(DR-AZ)*0.017453293
16300 C WK=RADIAN(DR-AZ)
16400 YR=XR*SIN(WK)
16500 XR=XR*COS(WK)
16600 JX1(N1)=XN1*SUSC+XR
16700 JY1(N1)=YN1*SUSC+YR
16800 JZ1(N1)=ZN1*SUSC+ZR
16900 XN(N1)=XN1
17000 YN(N1)=YN1
17100 ZN(N1)=ZN1
17200 HN(N1)=HN1
17300 FN(N1)=FN1
17400 DN(N1)=DN1
17500 15 CONTINUE
17600 C END READ CONSTANTS
17700 16 CONTINUE
17800 C NEW BODY
17900 WRITE(6,112)
18000 112 FORMAT(1H1)
18100 C SKIP TO TOP OF FORM
18200 WRITE(6,113)
18300 113 FORMAT(" BODY:"/6X,"Z",5X,"NV",6X,5("X",8X,"Y",10X))
18400 READ(5,114) NC
18500 114 FORMAT(I3)
18600 I=NC-1
18700 ND=INT(I/2)
18800 IF (2*ND .EQ. I) GOTO 17
18900 WRITE(6,115)
19000 115 FORMAT(" SHOULD BE ODD NUMBER OF LAYERS")
19100 STOP
19200 17 CONTINUE
19300 CT=0
19400 IF2TEM=AV+BV+2
19500 FM=AH+BH+2
19600 DO 23 I=1,NC
19700 READ(5,116) A,M
19800 116 FORMAT(F8.2,I4)
19900 ZA(I)=-A*UV
20000 NV(I)=M
20100 WRITE(6,117) IF2TEM,BV,A,M
20200 117 FORMAT(1H,"F*.*",I5)
20300 IF (M .EQ. 1) GOTO 22
20400 DY1I=0
20500 MO=CT+1
20600 CT=CT+M
20700 BUFCNT=0
20800 DO 20 J=MO,CT
20900 READ(5,118) B,C
21000 118 FORMAT(2F8.3)
21100 BUFCNT=BUFCNT+1
21200 BBUF(BUFCNT)=B
21300 CBUF(BUFCNT)=C
21400 XA(J)=B*UH
21500 YA(J)=C*UH
21600 DY1I=DY1I+1
21700 IF (MOD(DY1I,5) .NE. 0) GOTO 19
21800 WRITE(6,119) (FM,BH,BBUF(IBUF),FM,BH,CBUF(IBUF),IBUF=1,5)
21900 119 FORMAT(1H+,11X,10(2X,F*.*)/)
22000 BUFCNT=0
22100 19 CONTINUE
22200 20 CONTINUE
22300 IF (BUFCNT .NE. 0) WRITE(6,120) (FM,BH,BBUF(IBUF),FM,BH,
22400 CBUF(IBUF),IBUF=1,BUFCNT)
22500 120 FORMAT(1H+,11X,10(2X,F*.*)/)
22600 CT=CT+1
22700 XA(CT)=XA(MO)
22800 YA(CT)=YA(MO)
22900 22 CONTINUE
23000 C END READ COORDS FOR CONTOURS
23100 23 CONTINUE
23200 J=1
23300 DO 25 I=1,ND
23400 H3=ZA(J+1)
23500 H1=ZA(J)-H3
23600 H2=H3-ZA(J+2)
23700 H3=H1+H2

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23800      IF (H1 .LE. 0) GOTO 24
23900      H1=-H1
24000      H2=-H2
24100      H3=-H3
24200      24 CONTINUE
24300      Q1(I)=H3*(H2/H1-2)
24400      Q2(I)=-H3*H3*(H1+H2)
24500      Q3(I)=H3*(H1/H2-2)
24600      J=J+2
24700      C END I LOOP
24800      25 CONTINUE
24900      C WHAT TO DO WITH NEXT BODY
25000      READ(5,121) NPROB,NCPT,RPLACE,NCONST
25100      121 FORMAT(4I2)
25200      NEWPRB=NPROB .NE. 0
25300      NEWCP=NCPT .NE. 0
25400      REPLAC=RPLACE .NE. 0
25500      NUCNST=NCONST .NE. 0
25600      NF=.NOT. FIRST
25700      NR=.NOT. REPLAC
25800      C CALCULATE C. OF G.
25900      CT=0
26000      DO 28 I=1,NC
26100      SUMX=0.0
26200      SUMY=0.0
26300      SUMV=0.0
26400      M=NV(I)
26500      IF (M .EQ. 1) GOTO 27
26600      MD=CT+1
26700      CT=CT+M
26800      DO 26 J=MD,CT
26900      X1=XA(J)
27000      X2=XA(J+1)
27100      Y1=YA(J)
27200      Y2=YA(J+1)
27300      CP=X1*Y2-X2*Y1
27400      SUMV=SUMV+CP
27500      SUMX=SUMX+CP*(X1+X2)
27600      SUMY=SUMY+CP*(Y1+Y2)
27700      26 CONTINUE
27800      CT=CT+1
27900      27 CONTINUE
28000      V(I)=SUMV
28100      XAA(I)=SUMX
28200      YAA(I)=SUMY
28300      ZAA(I)=ZC(I)*SUMV
28400      C END I LOOP
28500      28 CONTINUE
28600      V1=INTEGL(V)
28700      ZL=-INTEGL(ZAA)/V1
28800      A=3.*V1
28900      XL=INTEGL(XAA)/A
29000      YL=INTEGL(YAA)/A
29100      V1=V1/2.
29200      XLL=XL/UH
29300      YLL=YL/UH
29400      ZLL=ZL/UV
29500      WRITE(6,122) V1,FM,RH,XLL,FM,BH,YLL,IF2TEM,BV,ZLL
29600      122 FORMAT(/,41X,"-",16X,"-",16X,"-"/" VOLUME = ",E10.4," C.C.",
29700      .16X,"X = ",F*,5X,"Y = ",F*,5X,"Z = ",F*,5X)
29800      IF (.NOT. NF) GOTO 29
29900      WRITE(6,123)
30000      123 FORMAT(57X,"-",9X,"-",9X,"-")
30100      WRITE(6,124)
30200      124 FORMAT(1H,29X,"CUMULATIVE: MASS",10X,"X",9X,"Y",9X,"Z")
30300      29 CONTINUE
30400      WRITE(6,125)
30500      125 FORMAT(1H,4X,"DENSITY",4X,"MASS")
30600      DO 31 N1=1,NC0
30700      ML=DENS(N1)*V1
30800      WRITE(6,126) DENS(N1),ML
30900      126 FORMAT(1H,F10.3,E12.4)
31000      IF (.NOT. NF) GOTO 30
31100      D=MC+ML
31200      A=(MC*XC+ML*XL)/D
31300      B=(MC*YC+ML*YL)/D
31400      C=(MC*ZC+ML*ZL)/D
31500      AAH=A/UH
31600      BRH=B/UH
31700      CCV=C/UV

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WRITE(6,127) D,FM,BH,AAH,FM,BH,BBH,IF2TEM,BV,CCV
127 FORMAT(1H+,37X,E10.4,4X,F*,*,2X,F*,*,2X,F*,*)
30 CONTINUE
WRITE(6,128)
128 FORMAT(/)
C END N1 LOOP
31 CONTINUE
IF (.NOT. FIRST) GOTO 32
MC=ML
XC=XL
YC=YL
ZC=ZL
GOTO 33
32 CONTINUE
IF (.NOT. NR) GOTO 33
MC=D
XC=A
YC=B
ZC=C
33 CONTINUE
C END OF C.G.
C C C C
C CALCULATE ANOMALIES
I=3
IF (FIRST) I=2
NCP=INT(56/(1+I*NCP))
CPC=NCP
EPSLNH=UH*1.E-6
EPSLNV=UV*1.E-6
XX=0
YY=0
ZZ=0
DO 80 M1=1,NP
XX=XX-X(M1)
YY=YY-Y(M1)
ZZ=ZZ-Z(M1)
CT=0
DO 63 I=1,NC
ZA(I)=ZA(I)+ZZ
M=NV(I)
IF (M.EQ. 1) GOTO 62
MO=CT+1
CT=MO+M
DO 61 J=MO,CT
XA(J)=XA(J)+XX
YA(J)=YA(J)+YY
61 CONTINUE
62 CONTINUE
C END I LOOP
63 CONTINUE
XX=X(M1)
YY=Y(M1)
ZZ=Z(M1)
CT=0
DO 74 I=1,NC
M=NV(I)
IF (M.NE. 1) GOTO 64
U(I)=0
UX(I)=0
UY(I)=0
UZ(I)=0
U1(I)=0
U2(I)=0
U3(I)=0
U4(I)=0
U5(I)=0
U6(I)=0
Z3(I)=0
GOTO 75
C GOTO OLD NEW I LABEL
64 CONTINUE
Z1=ZA(I)
Z2=Z1*Z1
BC=ABS(Z1) .GT. EPSLNV
MO=CT+1
CT=CT+M
X1=XA(MO)
Y1=YA(MO)
SQ=X1*X1+Y1*Y1

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39800      RX1=SQRT(SQ)
39900      R1=SQRT(SQ+Z2)
40000      R1I=1.0/R1
40100      UA=0
40200      UX1=0
40300      UY1=0
40400      UZ1=0
40500      S1=0
40600      S2=0
40700      S3=0
40800      S4=0
40900      S5=0
41000      S6=0
41100      U1=0
41200      D3=0
41300      DO 73 J=MD,CT
41400      X2=XA(J+1)
41500      Y2=YA(J+1)
41600      SQ=X2*X2+Y2*Y2
41700      RX2=SQRT(SQ)
41800      R2=SQRT(SQ+Z2)
41900      R2I=1.0/R2
42000      DX1=X1-X2
42100      DY1=Y1-Y2
42200      R12=SQRT(DX1*DX1+DY1*DY1)
42300      P=(X1*Y2-X2*Y1)/R12
42400      SQ=P*P
42500      ZPP=Z2+SQ
42600      COSG=(DX1*X2+DY1*Y2)/(R12*RX2)
42700      COSB=(DX1*X1+DY1*Y1)/(R12*RX1)
42800      BA=ABS(P) .GT. EPSLNH
42900      C   BA=BIG(P)
43000      IF (ABS(DY1) .GT. EPSLNH) GOTO 66
43100      C   IF (BIG(DY1)) GOTO 66
43200      IF (.NOT. BA) GOTO 65
43300      TERM=(X2*R2I-X1*R1I)/ZPP
43400      S4=S4+TERM*Y1
43500      S5=S5+TERM
43600      UY1=UY1+ALOG((X2+R2)/(X1+R1))
43700      65 CONTINUE
43800      GOTO 48
43900      C GOTO OLD POLAR LABEL
44000      66 CONTINUE
44100      EN=DX1/DY1
44200      G1=X1-Y1*EN
44300      ENSQ=EN*EN+1.0
44400      RT=SQRT(ENSQ)
44500      IRT=1.0/RT
44600      BB=BA .OR. BC
44700      TERM=EN*G1*IRT
44800      IF (.NOT. BB) GOTO 320
44900      SUM=(RT*Y2+R2*EN-TERM)/(RT*Y1+R1+TERM)
45000      GOTO 321
45100      320 SUM=Y1/Y2
45200      321 CONTINUE
45300      UX1=UX1-IRT*ALOG(SUM)
45400      IF (ABS(DX1) .LE. EPSLNH) GOTO 67
45500      C   IF (.NOT. BIG(DX1)) GOTO 67
45600      TERM=G1*IRT
45700      IF (.NOT. BB) GOTO 322
45800      SUM=(RT*X2+R2*EN-TERM)/(RT*X1+R1*EN-TERM)
45900      GOTO 323
46000      322 SUM=X1/X2
46100      323 CONTINUE
46200      UY1=UY1+EN*IRT*ALOG(SUM)
46300      67 CONTINUE
46400      IF (.NOT. BA) GOTO 68
46500      FACTOR=1.0/(ENSQ*ZPP)
46600      TERM=EN*Z2
46700      SUM=(G1*Y2-TERM)*R2I-(G1*Y1-TERM)*R1I
46800      S1=S1-FACTOR*SUM
46900      TERM=G1*G1+Z2
47000      CF=G1*EN
47100      SUM=(TERM+CF*Y2)*R2I-(TERM+CF*Y1)*R1I
47200      S2=S2+FACTOR*SUM
47300      SUM=(ENSQ*Y2+CF)*R2I-(ENSQ*Y1+CF)*R1I
47400      S3=S3-FACTOR*SUM
47500      SUM=(G1*X2+Z2)*R2I-(G1*X1+Z2)*R1I
47600      S4=S4-EN*FACTOR*SUM
47700      SUM=(ENSQ*X2-G1)*R2I-(ENSQ*X1-G1)*R1I

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S5=S5+FACTOR*SUM
GOTO 70
68 CONTINUE
TERM=(R2I-R1I)/ENSQ
S1=S1+TERM*EN
S2=S2+TERM
S4=S4-TERM*EN
IF (.NOT. BC) GOTO 69
S3=S3-(Y2*R2I-Y1*R1I)/ZPP
S5=S5+(X2*R2I-X1*R1I)/ZPP
69 CONTINUE
70 CONTINUE
48 CONTINUE
C OLD POLAR LABEL
IF (.NOT. BA) GOTO 72
CF=Z1/SQRT(ZPP)
BETA=ANGLE(X1,Y1,RX1,BA)
GAMMA=ANGLE(X2,Y2,RX2,BB)
DPSI=GAMMA-BETA
SUM=DPSI+ANGLEE(COSG)-ANGLEE(COSB)
UZ1=UZ1+SUM*FSIGN(P)
PP=FRT(RX1)
Q=FRT(RX2)
IF (.NOT. BC) GOTO 71
CF=ABS(P/Z1)
D1=D1+(ARC(GAMMA,Q,R2)-ARC(BETA,PP,R1)-DPSI)*FSIGN(P)
71 CONTINUE
IF (BA) PP=-PP
IF (BB) Q=-Q
UA=UA+P*ALOG((R1+PP)/(R2+Q))
TERM=RX2*COSG*R2I
CF=RX1*COSB*R1I
G1=(CF-TERM)*P/ZPP
S6=S6+G1
SUM=CF/(R1*R1)-TERM/(R2*R2)
D3=D3+(2.0*G1+P*SUM)/ZPP
C IF (.NOT. BA) GOTO HERE
72 CONTINUE
X1=X2
Y1=Y2
RX1=RX2
R1=R2
R1I=R2I
73 CONTINUE
C END J LOOP
CT=CT+1
U(I)=ABS(Z1)*D1+UA
UX(I)=UX1
UY(I)=UY1
UZ(I)=UZ1
U1(I)=S1
U2(I)=S2
U3(I)=S3*Z1
U4(I)=S4
U5(I)=S5*Z1
U6(I)=S6
Z3(I)=D3*Z1
75 CONTINUE
C OLD NEW LABEL
74 CONTINUE
C END OF I LOOP
UA=INTEGL(U)
UX1=INTEGL(UX)
UY1=INTEGL(UY)
UZ1=-INTEGL(UZ)
S1=INTEGL(U1)
S2=INTEGL(U2)
S3=-INTEGL(U3)
S4=INTEGL(U4)
S5=-INTEGL(U5)
S6=INTEGL(U6)
D3=-INTEGL(Z3)
SUM=(S1+S4+S6)
IF (CPC.NE.NCP) GOTO 76
WRITE(6,129)
129 FORMAT(1H1)
WRITE(6,130)
130 FORMAT(' COMPTG PT',8X,'G',7X,'GI',9X,'N',7X,
.'E',7X,'GZZ',13X,'V',9X,'H',9X,'F',7X,'D')
CPC=0

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55800      76 CONTINUE
55900      CPC=CPC+1
56000      WRITE(6,131) PPC(M1)
56100  131  FORMAT(1H,17)
56200      DO 78 N1=1,NC0
56300      JX=JX1(N1)
56400      JY=JY1(N1)
56500      JZ=JZ1(N1)
56600      DX=DP(S1,S2,S3)
56700      DY=DP(S2,S4,S5)
56800      DZ=DP(S3,S5,S6)
56900      A=K*DENS(N1)
57000      G=-UZ1*A*1.E3
57100      GI=G-(UA*A*3.149E-6)
57200      GZZ=-D3*A*1.E15
57300      A=NUMBER*A
57400      N=UX1*A
57500      E=UY1*A
57600      A=N*CS-E*SN
57700      E=N*SN+E*CS
57800      N=A
57900      CALL DELTA(DX,DY,DZ)
58000      WRITE(6,132) G,GI,N,E,GZZ,(BBJF(IBUF),IBUF=1,4)
58100  132  FORMAT(1H,11X,2F9.2,2F8.0,F10.1,6X,3F10.0,F9.1)
58200      IF (.NOT. NF .OR. N1 .NE. NC0) GO TO 77
58300      CALL DELTA(DXC(M1)+DX,DYC(M1)+DY,DZC(M1)+DZ)
58400      GCTEM=GC(M1)+G
58500      GICTEM=GIC(M1)+GI
58600      NCUTEM=NCU(M1)+N
58700      ECUTEM=ECU(M1)+E
58800      GZZTEM=GZZC(M1)+GZZ
58900      WRITE(6,133) GCTEM,GICTEM,NCUTEM,ECUTEM,GZZTEM,(BBUF(IBUF),IBUF=
59000      4)
59100  133  FORMAT(12X,2F9.2,2F8.0,F10.1,6X,3F10.0,F9.1)
59200      77 CONTINUE
59300      WRITE(6,134)
59400  134  FORMAT(/)
59500  C END N1 LOOP
59600      78 CONTINUE
59700      IF (.NOT. FIRST) GO TO 79
59800      CALL PLANT(DX,DY,DZ,G,GI,N,E,GZZ)
59900      GO TO 80
60000      79 CONTINUE
60100      IF (NR) CALL PLANT(DXC(M1)+DX,
60200      .DYC(M1)+DY,DZC(M1)+DZ,GC(M1)+G,
60300      .GIC(M1)+GI,NCU(M1)+N,ECU(M1)+E,GZZC(M1)+GZZ)
60400      80 CONTINUE
60500  C END M1 LOOP
60600  C END ANOMALIES
60700      FIRST=NEWPRB .OR. NEWCP .OR. (FIRST .AND. REPLAC)
60800      GO TO 999
60900  CGOTO OLD REPEAT LABEL
61000      END
61100  C END MAIN PROGRAM
61200  C
61300  C
61400  C INSERTED RADIAN IN LINE FOR SPEED
61500  C REAL FUNCTION RADIAN(A)
61600  C RADIAN=A*0.017453293
61700  C RETURN
61800  C END
61900  C REAL FUNCTION INTEGL(A)
62000  C DIMENSION A(2)
62100  C INTEGER K,J
62200  C REAL I,W
62300  C COMMON /INTGRL/ Q1(7),Q2(7),Q3(7),NC
62400  C I=0
62500  C K=1
62600  C J=1
62700  10 CONTINUE
62800  C W=Q1(K)*A(J)
62900  C J=J+1
63000  C W=W+Q2(K)*A(J)
63100  C J=J+1
63200  C I=I+W+Q3(K)*A(J)
63300  C K=K+1
63400  C IF (K-NO .LT. 1) GO TO 10
63500  C INTEGL=I/6.
63600  C RETURN
63700  C

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63800 C INSERTED BIG IN LINE FOR SPEED
63900 C FUNCTION BIG(XA)
64000 C LOGICAL BIG
64100 C COMMON /BIGCOM/ EPSLNH
64200 C BIG=ABS(XA) .GT. EPSLNH
64300 C RETURN
64400 C END
64500 REAL FUNCTION ANGLE(XA,YA,R,B)
64600 LOGICAL B,BB
64700 COMMON /WKSP/PP,Q,W,BB,P,PIBY2,DX1,DY1,PI,CF,SQ
64800 W=ABS(P)/R
64900 IF (W .GE. 1.) GOTO 10
65000 W=ARSIN(W)
65100 GOTO 20
65200 10 W=PIBY2
65300 20 CONTINUE
65400 B=(XA*DX1+YA*DY1) .LT. 0.0
65500 BB=B
65600 IF(BB) W=PI-W
65700 ANGLE=W
65800 RETURN
65900 END
66000 REAL FUNCTION ANGLEF(CCOS)
66100 COMMON /WKSP/PP,Q,W,BB,P,PIBY2,DX1,DY1,PI,CF,SQ
66200 LOGICAL BB
66300 W=CF*CCOS
66400 IF (ABS(W) .LT. 1.) GOTO 10
66500 ANGLEE=FSIGN(W)*PIBY2
66600 RETURN
66700 10 ANGLEE=ARSIN(W)
66800 RETURN
66900 END
67000 REAL FUNCTION FRT(R)
67100 COMMON /WKSP/PP,Q,W,BB,P,PIBY2,DX1,DY1,PI,CF,SQ
67200 LOGICAL BB
67300 W=R*R-SQ
67400 FRT=0
67500 IF (W .GT. 0) FRT=SQRT(W)
67600 RETURN
67700 END
67800 REAL FUNCTION ARC(ETA,L,RR)
67900 REAL ETA,L,RR
68000 COMMON /WKSP/PP,Q,W,BB,P,PIBY2,DX1,DY1,PI,CF,SQ
68100 LOGICAL BB
68200 IF ( L .LE. 0.) GOTO 10
68300 W=PIBY2-ATAN(CF*RR/L)
68400 IF (ETA .LT. PI) W=-W
68500 ARC=W
68600 RETURN
68700 10 W=0
68800 ARC=W
68900 RETURN
69000 END
69100 REAL FUNCTION DP(A,B,C)
69150 REAL JX,JY,JZ
69200 COMMON /FC TDP/ JX,JY,JZ
69300 DP=JX*A+JY*B+JZ*C
69400 RETURN
69500 END
69600 SUBROUTINE DELTA(DX,DY,DZ)
69700 REAL XT,YT,ZT,H,HAN,FAN,DAN
69800 COMMON /DLTA/ N1,XN(10),YN(10),ZN(10),BBUF(5),
69900 DN(10),HN(10),FN(10),AZ
70000 XT=DX+XN(N1)
70100 YT=DY+YN(N1)
70200 ZT=DZ+ZN(N1)
70300 H=SQRT(XT*XT+YT*YT)
70400 C H=RMOD(XT,YT)
70500 HAN=H-HN(N1)
70600 FAN=SQRT(H*H+ZT*ZT)-FN(N1)
70700 C FAN=RMOD(H,ZT)-FN(N1)
70800 DAN=60.0*(57.2957795*ARSIN(YT/H)-DN(N1)+AZ)
70900 BBUF(1)=DZ
71000 BBUF(2)=HAN
71100 BBUF(3)=FAN
71200 BBUF(4)=DAN
71300 RETURN
71400 END
71500 C
71600 C PLACED IN LINE FOR SPEED

```

71700
71800
71900
72000
72100
72200
72300
72400
72500
72600
72700
72800
72900
73000
73100
73200
73300
73400
73500
73600
73700
73800
73900
74000
74100
74200
74300
74400

C
C
C

```

REAL FUNCTION RMOD(XA, YA)
RMOD=SQRT(XA*XA+YA*YA)
RETURN
END
SUBROUTINE PLANT(A, B, C, D, PP, Q, RR, S)
REAL A, NCU, B, C, D, PP, Q, RR, S
COMMON /PLNT/M1, DXC(100), DYC(100), DZC(100),
  GIC(100), NCU(100), ECU(100), GC(100), GZC(100)
DXC(M1)=A
GIC(M1)=PP
DYC(M1)=B
NCU(M1)=Q
DZC(M1)=C
ECU(M1)=RR
GC(M1)=D
GZC(M1)=S
RETURN
END
REAL FUNCTION FSIGN(A)
IF (A .EQ. 0.) GOTO 10
IF (A .GT. 0.) GOTO 20
FSIGN=-1.
RETURN
10 FSIGN=0
RETURN
20 FSIGN=1.
RETURN
END

```

```

100  $SET $
200  $SET LINEINFO
300  $RESET FREE
400  FILE 6(KIND=PRINTER)
500  FILE 5(TITLE="U1776/DATA",KIND=PACK,FILETYPE=7)
600  C U2588 SOLID 3-D GRAVITATIONAL ATTRACTION
700  C TRANSLATED FROM THE ALGOL VERSION D.S.I.R. GEOPHYSICS DIVISION.
800  C GPO30 SOLID.
900  C TALWANI METHOD FOR CALCULATING THE GRAVITY AND MAGNETIC EFFECTS
1000 C OF A BODY OF ARBITRARY SHAPE APPROXIMATED BY POLYGONAL CONTOURS
1100 C VIDE TALWANI, EWING, 1959:
1200 C <RAPID COMPUTATION OF GRAVITATIONAL ATTRACTION OF THREE-DIMENSIONAL
1300 C BODIES OF ARBITRARY SHAPE>
1400 C IN GEOPHYSICS, VOL. XXV, NO. 1 (FEBRUARY 1960).
1500 C TALWANI, M., 1964:
1600 C COMPUTATION WITH THE HELP OF A DIGITAL COMPUTER OF MAGNETIC
1700 C ANOMALIES CAUSED BY BODIES OF ARBITRARY SHAPE>
1800 C IN GEOPHYSICS, VOL. XXX, NO. 5 (OCTOBER 1965).
1900 C PROGRAMME WRITTEN BY M.A. SAUNDERS, D.S.I.R. APPLIED MATHEMATICS
2000 C DIVISION, SEPTEMBER 1966 . . . AND ALTERED FOR THE UNIVERSITY OF
2100 C TASMANIA 86700 BY R.G. RICHARDSON (1978 BOTH ALGOL AND FORTRAN).
2200 C GRAVITY ONLY
2300   LOGICAL NEWPRB, NEWCP, REPLAC, NUCNST, FIRST, NF, NR
2400   INTEGER I, BUF CNT, I BUF, J, M1, N1, JH1, UV1, NP, NC, ND,
2500   . NCD, FM, M, AH, BH, AV, RV, NPROB, NCPT,
2600   . RPLAC, NCONST, CT, MD, DY1I, NCP, CPC
2700   REAL UH, UV, XX, YY, ZZ, X1, X2, Y1, Y2, PI,
2800   . PIBY2, AZ, K, NUMBER, H1, H2, H3, MC, XC, YC, ZC, A, B, C, D, SN, CS
2900   REAL SCALE(7), V(100), BBUF(5), CBUF(5), X(100), Y(100), Z(100),
3000   . GC, GIC, NCU, ECU, GZZC,
3100   . DENS(10), XA(450), YA(450), ZA(15), Q1, Q2, Q3
3200   INTEGER A1(7), B1(7), PPC(101), TITLE(80), NV(15)
3300   REAL XAA(200), YAA(200), ZAA(200), XL, YL, ZL, ML, CP,
3400   . SUMX, SUMY, SUMV, V1
3500 C XAA, YAA, ZAA, U, UX, . . . 73 ARE DIMENSIONED TO LARGEST
3600 C NUMBER OF CONTOURS
3700   REAL U(100), UX(100), UY(100), UZ(100),
3800   . Z3(100), UA, UX1, UY1, UZ1,
3900   . D1, D3, TERM, SUM, Z1, Z2, RX1, RX2, R12, R1, R2, R1I, R2I,
4000   . EPSLNH, EPSLNV, SQ, CF, DX1, DY1, EN, G1, ENSQ, RT, P, ZPP,
4100   . IRT, COSG, COSB, BETA, GAMMA, DPSI, INTEGL, G, GI, N, E, GZZ
4200   LOGICAL BA, BB, BC
4300   REAL PP, Q, W, NCUTEM
4400   COMMON /INTGRL/ Q1(7), Q2(7), Q3(7), ND
4500   COMMON /WKSP/ PP, Q, W, BB, P, PIBY2, DX1, DY1, PI, CF, SQ
4600   COMMON /PLNT/ M1,
4700   . GIC(100), NCU(100), ECU(100), GC(100), GZZC(100)
4800   SCALE(5)=1.E5
4900   SCALE(4)=182.87984
5000   SCALE(6)=160934.3
5100   SCALE(1)=1.E2
5200   SCALE(2)=30.479973
5300   SCALE(3)=91.4399
5400   SCALE(7)=185318.2
5500   K=6.673E-8
5600   A1(1)=6
5700   A1(2)=6
5800   A1(3)=6
5900   A1(4)=6
6000   A1(5)=3
6100   A1(6)=3
6200   A1(7)=3
6300   B1(1)=0
6400   B1(2)=0
6500   B1(3)=0
6600   B1(3)=0
6700   B1(4)=0
6800   B1(5)=3
6900   B1(6)=3
7000   B1(7)=3
7100   PI=3.1415926536
7200   PIBY2=PI/2.
7300   NUMBER=-57.2957795*3600./980.
7400   NEWPRB=.TRUE.
7500   NEWCP=.TRUE.
7600   NUCNST=.TRUE.
7700   FIRST=.TRUE.

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7800      999 CONTINUE
7900      C OLD REPEAT LABEL
8000      IF (.NOT. NEWCP) GOTO 14
8100      C READ COMPUTING POINTS
8200      WRITE(6,100)
8300      100 FORMAT(/37X,"D.S.I.R. GEOPHYSICS DIVISION"/30X,"THREE-DIME",
8400      . "NSIONAL GRAVITY AND MAGNETICS EFFECTS")
8500      READ(5,101) TITLE
8600      WRITE(6,101) TITLE
8700      101 FORMAT(1X,80A1)
8800      READ(5,102) UH1,UV1,AZ
8900      102 FORMAT(2I2,F4.1)
9000      WRITE(6,103) UH1,UV1,AZ
9100      103 FORMAT(/" HORIZONTAL UNITS:",I3,6X,"VERTICAL UNITS:",I3,
9200      . 6X,"AZIMUTH:",F5.0," DEGREES")
9300      A=AZ*0.017453293
9400      C A=RADIAN(AZ)
9500      SN=SIN(A)
9600      CS=COS(A)
9700      UH1=UH1+1
9800      UV1=UV1+1
9900      AH=A1(UH1)
10000     BH=B1(UH1)
10100     AV=A1(UV1)
10200     BV=B1(UV1)
10300     UH=SCALE(UH1)
10400     UV=SCALE(UV1)
10500     WRITE(6,104)
10600     104 FORMAT(/" COMPUTING POINTS:"/5X,"NO",7X,"X",9X,"Y",9X,"Z")
10700     I=0
10800     NP=0
10900     10 CONTINUE
11000     I=I+1
11100     NP=NP+1
11200     READ(5,105) PPC(I),A,B,C
11300     105 FORMAT(I4,3F8.3)
11400     IF (PPC(I) .LT. 0) GOTO 11
11500     IF1TEM=AH+BH+4
11600     IF2TEM=AV+BV+4
11700     WRITE(6,106) PPC(I),IF1TEM,BH,A,B,IF2TEM,BV,C
11800     106 FORMAT(1X,I6,2F*,*,F*,*)
11900     A=A+1.E-6
12000     X(I)=A*UH
12100     Y(I)=B*UH
12200     Z(I)=-C*UV
12300     GOTO 10
12400     11 I=I-1
12500     NP=NP-1
12600     C END READ COMPUTING POINTS
12700     14 CONTINUE
12800     IF (.NOT. NUCNST) GOTO 16
12900     C READ CONSTANTS
13000     READ(5,107) NCO
13100     107 FORMAT(I2)
13200     IF (NCO .LE. 0) STOP
13300     WRITE(6,108)
13400     108 FORMAT(1H1)
13500     C NEW PAGE
13600     WRITE(6,109)
13700     109 FORMAT(/" CONSTANTS:"/6X,"DENSITY")
13800     DO 15 N1=1,NCO
13900     READ(5,110) DENS(N1)
14000     110 FORMAT(F6.3)
14100     WRITE(6,111) DENS(N1)
14200     111 FORMAT(1X,F11.3)
14300     15 CONTINUE
14400     C END READ CONSTANTS
14500     16 CONTINUE
14600     C NEW BODY
14700     WRITE(6,112)
14800     112 FORMAT(1H1)
14900     C SKIP TO TOP OF FORM
15000     WRITE(6,113)
15100     113 FORMAT(" BODY:"/6X,"Z",5X,"NV",6X,5("X",8X,"Y",10X))
15200     READ(5,114) NC
15300     114 FORMAT(I3)
15400     I=NC-1
15500     ND=INT(I/2)
15600     IF (2*ND .EQ. I) GOTO 17
15700     WRITE(6,115)

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15800 115 FORMAT(" SHOULD BE ODD NUMBER OF LAYERS")
15900 STOP
16000 17 CONTINUE
16100 CT=0
16200 IF 2TEM=AV+BV+2
16300 FM=AH+BH+2
16400 DO 23 I=1,NC
16500 READ(5,116) A,M
16600 116 FORMAT(F8.2,I4)
16700 ZA(I)=-A*UV
16800 NV(I)=M
16900 WRITE(6,117) IF 2TEM,BV,A,M
17000 117 FORMAT(1H,F*.*,I5)
17100 IF (M.EQ. 1) GOTO 22
17200 DY1I=0
17300 MD=CT+1
17400 CT=CT+M
17500 BUFCNT=0
17600 DO 20 J=MD,CT
17700 READ(5,118) B,C
17800 118 FORMAT(2F8.3)
17900 BUFCNT=BUFCNT+1
18000 BBUF(BUFCNT)=B
18100 CBUF(BUFCNT)=C
18200 XA(J)=B*UH
18300 YA(J)=C*UH
18400 DY1I=DY1I+1
18500 IF (MOD(DY1I,5).NE. 0) GOTO 19
18600 WRITE(6,119) (FM,BH,BBUF(IBUF),FM,BH,CBUF(IBUF),IBUF=1,5)
18700 119 FORMAT(1H+,11X,10(2X,F*.*))
18800 BUFCNT=0
18900 19 CONTINUE
19000 20 CONTINUE
19100 IF (BUFCNT.NE. 0) WRITE(6,120) (FM,BH,BBUF(IBUF),FM,BH,
19200 CBUF(IBUF),IBUF=1,BUFCNT)
19300 120 FORMAT(1H+,11X,10(2X,F*.*))
19400 CT=CT+1
19500 XA(CT)=XA(MD)
19600 YA(CT)=YA(MD)
19700 22 CONTINUE
19800 C END READ COORDS FOR CONTOURS
19900 23 CONTINUE
20000 J=1
20100 DO 25 I=1,ND
20200 H3=ZA(J+1)
20300 H1=ZA(J)-H3
20400 H2=H3-ZA(J+2)
20500 H3=H1+H2
20600 IF (H1.LE. 0) GOTO 24
20700 H1=-H1
20800 H2=-H2
20900 H3=-H3
21000 24 CONTINUE
21100 Q1(I)=H3*(H2/H1-2)
21200 Q2(I)=-H3*H3*(H1+H2)
21300 Q3(I)=H3*(H1/H2-2)
21400 J=J+2
21500 C END I LOOP
21600 25 CONTINUE
21700 C WHAT TO DO WITH NEXT BODY
21800 READ(5,121) NPROB,NCPT,RPLAC,NCONST
21900 121 FORMAT(4I2)
22000 NEWPRB=NPROB.NE. 0
22100 NEWCP=NCPT.NE. 0
22200 REPLAC=RPLAC.NE. 0
22300 NCONST=NCONST.NE. 0
22400 NF=.NOT. FIRST
22500 NR=.NOT. REPLAC
22600 C CALCULATE C. OF G.
22700 CT=0
22800 DO 28 I=1,NC
22900 SUMX=0.0
23000 SUMY=0.0
23100 SUMV=0.0
23200 M=NV(I)
23300 IF (M.EQ. 1) GOTO 27
23400 MD=CT+1
23500 CT=CT+M
23600 DO 26 J=MD,CT
23700 X1=XA(J)

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23800      X2=XA(J+1)
23900      Y1=YA(J)
24000      Y2=YA(J+1)
24100      CP=X1*Y2-X2*Y1
24200      SUMV=SUMV+CP
24300      SUMX=SUMX+CP*(X1+X2)
24400      SUMY=SUMY+CP*(Y1+Y2)
24500  26  CONTINUE
24600      CT=CT+1
24700  27  CONTINUE
24800      V(I)=SUMV
24900      XAA(I)=SUMX
25000      YAA(I)=SUMY
25100      ZAA(I)=ZAC(I)*SUMV
25200  C  END  I  LOOP
25300  23  CONTINUE
25400      V1=INTEGL(V)
25500      ZL=INTEGL(ZAA)/V1
25600      A=3.*V1
25700      XL=INTEGL(XAA)/A
25800      YL=INTEGL(YAA)/A
25900      V1=V1/2.
26000      XLL=XL/UH
26100      YLL=YL/UH
26200      ZLL=ZL/UV
26300      WRITE(6,122) V1,FM,RH,XLL,FM,BH,YLL,IF2TEM,BV,ZLL
26400  122  FORMAT(/,41X,"-",16X,"-",16X,"-"/" VOLUME = ",E10.4," C.C.",
26500      .16X,"X = ",F*.**,5X,"Y = ",F*.**,5X,"Z = ",F*.**/)
26600      IF (.NOT. NF) GOTO 29
26700      WRITE(6,123)
26800  123  FORMAT(57X,"-",9X,"-",9X,"-")
26900      WRITE(6,124)
27000  124  FORMAT(1H,29X,"CUMULATIVE:  MASS",10X,"X",9X,"Y",9X,"Z")
27100  29  CONTINUE
27200      WRITE(6,125)
27300  125  FORMAT(1H,4X,"DENSITY",4X,"MASS")
27400      DO 31 N1=1,NC0
27500      ML=DENS(N1)*V1
27600      WRITE(6,126) DENS(N1),ML
27700  126  FORMAT(1H,F10.3,E12.4)
27800      IF (.NOT. NF) GOTO 30
27900      D=MC+ML
28000      A=(MC*XC+ML*XL)/D
28100      B=(MC*YC+ML*YL)/D
28200      C=(MC*ZC+ML*ZL)/D
28300      AAH=A/UH
28400      BBH=B/UH
28500      CCV=C/UV
28600      WRITE(6,127) D,FM,BH,AAH,FM,BH,BBH,IF2TEM,BV,CCV
28700  127  FORMAT(1H,37X,E10.4,4X,F*.**,2X,F*.**,2X,F*.**)
28800  30  CONTINUE
28900      WRITE(6,128)
29000  128  FORMAT(/)
29100  C  END  N1  LOOP
29200  31  CONTINUE
29300      IF (.NOT. FIRST) GOTO 32
29400      MC=ML
29500      XC=XL
29600      YC=YL
29700      ZC=ZL
29800      GOTO 33
29900  32  CONTINUE
30000      IF (.NOT. NR) GOTO 33
30100      MC=0
30200      XC=A
30300      YC=B
30400      ZC=C
30500  33  CONTINUE
30600  C  END  OF  C.G.
30700  C  C  C
30800  C  CALCULATE ANOMALIES
30900      I=3
31000      IF (FIRST) I=2
31100      NCP=INT(56/(1+I*NC0))
31200      CPC=NCP
31300      EPSLNH=UH*1.E-6
31400      EPSLNV=UV*1.E-6
31500      XX=0
31600      YY=0
31700

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31800 Z7=0
31900 DO 80 M1=1,NP
32000 XX=XX-X(M1)
32100 YY=YY-Y(M1)
32200 ZZ=ZZ-Z(M1)
32300 CT=0
32400 DO 63 I=1,NC
32500 ZA(I)=ZA(I)+ZZ
32600 M=NV(I)
32700 IF (M.EQ. 1) GOTO 62
32800 MD=CT+1
32900 CT=MD+M
33000 DO 61 J=MD,CT
33100 XA(J)=XA(J)+XX
33200 YA(J)=YA(J)+YY
33300 61 CONTINUE
33400 62 CONTINUE
33500 C END I LOGP
33600 63 CONTINUE
33700 XX=X(M1)
33800 YY=Y(M1)
33900 ZZ=Z(M1)
34000 CT=0
34100 DO 74 I=1,NC
34200 M=NV(I)
34300 IF (M.NE. 1) GOTO 64
34400 U(I)=0
34500 UX(I)=0
34600 UY(I)=0
34700 UZ(I)=0
34800 Z3(I)=0
34900 GOTO 75
35000 C GOTO OLD NEWI LABEL
35100 64 CONTINUE
35200 Z1=ZA(I)
35300 Z2=Z1*Z1
35400 BC=ABS(Z1) .GT. EPSLN
35500 MD=CT+1
35600 CT=CT+M
35700 X1=XA(MD)
35800 Y1=YA(MD)
35900 SQ=X1*X1+Y1*Y1
36000 RX1=SQRT(SQ)
36100 R1=SQRT(SQ+Z2)
36200 R1I=1.0/R1
36300 UA=0
36400 UX1=0
36500 UY1=0
36600 UZ1=0
36700 D1=0
36800 D3=0
36900 DO 73 J=MD,CT
37000 X2=XA(J+1)
37100 Y2=YA(J+1)
37200 SQ=X2*X2+Y2*Y2
37300 RX2=SQRT(SQ)
37400 R2=SQRT(SQ+Z2)
37500 R2I=1.0/R2
37600 DX1=X1-X2
37700 DY1=Y1-Y2
37800 R12=SQRT(DX1*DX1+DY1*DY1)
37900 P=(X1*Y2-X2*Y1)/R12
38000 SQ=P*P
38100 ZPP=Z2+SQ
38200 COSG=(DX1*X2+DY1*Y2)/(R12*RX2)
38300 COSB=(DX1*X1+DY1*Y1)/(R12*RX1)
38400 BA=ABS(P) .GT. EPSLNH
38500 C BA=BIG(P)
38600 IF (ABS(DY1) .GT. EPSLNH) GOTO 66
38700 C IF (BIG(DY1)) GOTO 66
38800 IF (.NOT. BA) GOTO 65
38900 UY1=UY1+ALOG((X2+R2)/(X1+R1))
39000 65 CONTINUE
39100 GOTO 48
39200 C GOTO OLD POLAR LABEL
39300 66 CONTINUE
39400 EN=DX1/DY1
39500 G1=X1-Y1*EN
39600 ENSQ=EN*EN+1.0
39700 RT=SQRT(ENSQ)

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39800 IRT=1.0/RT
39900 BB=BA .OR. BC
40000 TERM=EN*G1*IRT
40100 IF (.NOT. BB) GOTO 320
40200 SUM=(RT*Y2+R2+TERM)/(RT*Y1+R1+TERM)
40300 GOTO 321
40400 320 SUM=Y1/Y2
40500 321 CONTINUE
40600 UX1=UX1-IRT*ALOG(SUM)
40700 IF (ABS(DX1) .LE. EPSLNH) GOTO 67
40800 C IF (.NOT. BIG(DX1)) GOTO 67
40900 TERM=G1*IRT
41000 IF (.NOT. BB) GOTO 322
41100 SUM=(RT*X2+R2*EN-TERM)/(RT*X1+R1*EN-TERM)
41200 GOTO 323
41300 322 SUM=X1/X2
41400 323 CONTINUE
41500 UY1=UY1+EN*IRT*ALOG(SUM)
41600 67 CONTINUE
41700 IF (.NOT. BA) GOTO 68
41800 GOTO 70
41900 68 CONTINUE
42000 69 CONTINUE
42100 70 CONTINUE
42200 48 CONTINUE
42300 C OLD POLAR LABEL
42400 IF (.NOT. BA) GOTO 72
42500 CF=Z1/SQRT(ZPP)
42600 BETA=ANGLE(X1,Y1,RX1,BA)
42700 GAMMA=ANGLE(X2,Y2,RX2,BB)
42800 DPSI=GAMMA-BETA
42900 SUM=DPSI+ANGLEE(COSG)-ANGLEE(COSB)
43000 UZ1=UZ1+SUM*F SIGN(P)
43100 PP=FRT(RX1)
43200 Q=FRT(RX2)
43300 IF (.NOT. BC) GOTO 71
43400 CF=ABS(P/Z1)
43500 D1=D1+(ARC(GAMMA,Q,P2)-ARC(BETA,PP,R1)-DPSI)*F SIGN(P)
43600 71 CONTINUE
43700 IF (BA) PP=-PP
43800 IF (BB) Q=-Q
43900 UA=UA+P*ALOG((R1+PP)/(R2+Q))
44000 TERM=RX2*COSG*R2I
44100 CF=RX1*COSB*R1I
44200 G1=(CF-TERM)*P/ZPP
44300 SUM=CF/(R1*R1)-TERM/(R2*R2)
44400 D3=D3+(2.0*G1+P*SUM)/ZPP
44500 C IF (.NOT. BA) GOTO HERE
44600 72 CONTINUE
44700 X1=X2
44800 Y1=Y2
44900 RX1=RX2
45000 R1=R2
45100 R1I=R2I
45200 73 CONTINUE
45300 C END J LOOP
45400 CT=CT+1
45500 U(I)=ABS(Z1)*D1+UA
45600 UX(I)=UX1
45700 UY(I)=UY1
45800 UZ(I)=UZ1
45900 Z3(I)=D3*Z1
46000 75 CONTINUE
46100 C OLD NEWI LABEL
46200 74 CONTINUE
46300 C END OF I LOOP
46400 UA=INTEGL(U)
46500 UX1=INTEGL(UX)
46600 UY1=INTEGL(UY)
46700 UZ1=-INTEGL(UZ)
46800 D3=-INTEGL(Z3)
46900 IF (CPC .NE. NCP) GOTO 76
47000 WRITE(6,129)
47100 129 FORMAT(1H1)
47200 WRITE(6,130)
47300 130 FORMAT(' CUMPTG PT',8X,'G',7X,'GI',9X,'N',7X,
47400 'E',7X,'GZZ')
47500 CPC=0
47600 76 CONTINUE
47700 CPC=CPC+1

```

```

47800 WRITE(6,131) PPC(M1)
47900 131 FORMAT(1H,17)
48000 DO 78 N1=1,NC0
48100 A=K*DENS(N1)
48200 G=-UZ1*A*1.E3
48300 GI=G-(UA*A*3.149E-6)
48400 GZZ=-D3*A*1.E15
48500 A=NUMBER*A
48600 N=UX1*A
48700 E=UY1*A
48800 A=N*CS-E*SN
48900 E=N*SN+E*CS
49000 N=A
49100 WRITE(6,132) G,GI,N,E,GZZ
49200 132 FORMAT(1H+,11X,2F9.2,2F8.0,F10.1)
49300 IF (.NOT. NF .OR. N1 .NE. NC0) GOTO 77
49400 GCTEM=GC(M1)+G
49500 GICTEM=GIC(M1)+GI
49600 NCUTEM=NCU(M1)+N
49700 ECUTEM=ECU(M1)+E
49800 GZZTEM=GZZC(M1)+GZZ
49900 WRITE(6,133) GCTEM,GICTEM,NCUTEM,ECUTEM,GZZTEM
49950 133 FORMAT(12X,2F9.2,2F8.0,F10.1)
50000 77 CONTINUE
50100 WRITE(6,134)
50200 134 FORMAT(/)
50300 C END N1 LOOP
50400 78 CONTINUE
50500 IF (.NOT. FIRST) GOTO 79
50600 CALL PLANT(G,GI,N,E,GZZ)
50700 GOTO 80
50800 79 CONTINUE
50900 IF (NR) CALL PLANT(GC(M1)+G,
51000 .GIC(M1)+GI,NCU(M1)+N,ECU(M1)+E,GZZC(M1)+GZZ)
51100 80 CONTINUE
51200 C END M1 LOOP
51300 C END ANOMALIES
51400 FIRST=NEWPRB .OR. NEWCP .OR. (FIRST .AND. REPLAC)
51500 GOTO 999
51600 CGOTO OLD REPEAT LABEL
51700 END
51800 C END MAIN PROGRAM
51900 C
52000 C INSERTED RADIANT IN LINE FOR SPEED
52100 C REAL FUNCTION RADIANT(A)
52200 C RADIANT=A*0.017453297
52300 C RETURN
52400 C END
52500 C REAL FUNCTION INTEGL(A)
52600 C DIMENSION A(2)
52700 C INTEGER K,J
52800 C REAL I,W
52900 C COMMON /INTGRL/ Q1(7),Q2(7),Q3(7),ND
53000 C I=0
53100 C K=1
53200 C J=1
53300 10 CONTINUE
53400 W=Q1(K)*A(J)
53500 J=J+1
53600 W=W+Q2(K)*A(J)
53700 J=J+1
53800 I=I+W+Q3(K)*A(J)
53900 K=K+1
54000 IF (K-ND .LT. 1) GOTO 10
54100 INTEGL=I/6.
54200 RETURN
54300 END
54400 C
54500 C INSERTED BIG IN LINE FOR SPEED
54600 C FUNCTION BIG(XA)
54700 C LOGICAL BIG
54800 C COMMON /BIGCOM/ EPSLNH
54900 C BIG=ABS(XA) .GT. EPSLNH
55000 C RETURN
55100 C END
55200 C REAL FUNCTION ANGLE(XA,YA,R,B)
55300 C LOGICAL B,BB
55400 C COMMON /WSP/PP,Q,W,BB,P,PIBY2,DX1,DY1,PI,CF,SQ
55500 C W=ABS(P)/R
55600 IF (W .GE. 1.) GOTO 10

```

```

55700      W=ARSIN(W)
55800      GOTO 20
55900      10 W=PIBY2
56000      20 CONTINUE
56100      B=(XA*DX1+YA*DY1) .LT. 0.0
56200      BB=B
56300      IF(BB) W=PI-W
56400      ANGLE=W
56500      RETURN
56600      END
56700      REAL FUNCTION ANGLEF(CCOS)
56800      COMMON /WKSP/PP,Q,W,BB,P,PIBY2,DX1,DY1,PI,CF,SQ
56900      LOGICAL BB
57000      W=CF*CCOS
57100      IF (ABS(W) .LT. 1.) GOTO 10
57200      ANGLEE=FSIGN(W)*PIBY2
57300      RETURN
57400      10 ANGLEE=ARSIN(W)
57500      RETURN
57600      END
57700      REAL FUNCTION FRT(R)
57800      COMMON /WKSP/PP,Q,W,BB,P,PIBY2,DX1,DY1,PI,CF,SQ
57900      LOGICAL BB
58000      W=R*R-SQ
58100      FRT=0
58200      IF (W .GT. 0) FRT=SQRT(W)
58300      RETURN
58400      END
58500      REAL FUNCTION ARC(ETA,L,RR)
58600      REAL ETA,L,RR
58700      COMMON /WKSP/PP,Q,W,BB,P,PIBY2,DX1,DY1,PI,CF,SQ
58800      LOGICAL BB
58900      IF (L .LE. 0.) GOTO 10
59000      W=PIBY2-ATAN(CF*RR/L)
59100      IF (ETA .LT. PI) W=-W
59200      ARC=W
59300      RETURN
59400      10 W=0
59500      ARC=W
59600      RETURN
59700      END
59800
59900      C
60000      C C C C C
60100      C PLACED IN LINE FOR SPEED
60200      C REAL FUNCTION RMOD(XA,YA)
60300      C RMOD=SQRT(XA*XA+YA*YA)
60400      C RETURN
60500      C END
60600      SUBROUTINE PLANT(D,PP,Q,RR,S)
60700      REAL NCU,D,PP,Q,RR,S
60800      COMMON /PLNT/M1,
60900      .GIC(100),NCU(100),FCU(100),GC(100),GZZC(100)
61000      GIC(M1)=PP
61100      NCU(M1)=Q
61200      FCU(M1)=RR
61300      GC(M1)=D
61400      GZZC(M1)=S
61500      RETURN
61600      END
61700      REAL FUNCTION FSIGN(A)
61800      IF (A .EQ. 0.) GOTO 10
61900      IF (A .GT. 0.) GOTO 20
62000      FSIGN=-1.
62100      RETURN
62200      10 FSIGN=0
62300      RETURN
62400      20 FSIGN=1.
        RETURN
        END

```

APPENDIX 5: Programme U2588/SIMPLE

KFILE: U2588 /SIMPLE (04/06/81)

```

100  $SET $
200  $SET LINEINFO
300  $RESET FREE
400  FILE 6(KIND=PRINTER)
500  FILE 5(TITLE="U1776/DATA",KIND=PACK,FILETYPE=7)
600  C U2588 SOLID 3-D GRAVITATIONAL ATTRACTION - SIMPLE VERSION
700  C TRANSLATED FROM THE ALGOL VERSION D.S.I.R. GEOPHYSICS DIVISION.
800  C GPU30 SOLID.
900  C TALWANI METHOD FOR CALCULATING THE GRAVITY AND MAGNETIC EFFECTS
1000 C OF A BODY OF ARBITRARY SHAPE APPROXIMATED BY POLYGONAL CONTOURS
1100 C VIDE TALWANI, EWING, 1959:
1200 C <RAPID COMPUTATION OF GRAVITATIONAL ATTRACTION OF THREE-DIMENSIONAL
1300 C BODIES OF ARBITRARY SHAPE>
1400 C IN GEOPHYSICS, VOL. XXV, NO. 1 (FEBRUARY 1960).
1500 C TALWANI, M., 1964:
1600 C COMPUTATION WITH THE HELP OF A DIGITAL COMPUTER OF MAGNETIC
1700 C ANOMALIES CAUSED BY BODIES OF ARBITRARY SHAPE>
1800 C IN GEOPHYSICS, VOL. XXX, NO. 5 (OCTOBER 1965).
1900 C PROGRAMME WRITTEN BY M.A. SAUNDERS, D.S.I.R. APPLIED MATHEMATICS
2000 C DIVISION, SEPTEMBER 1966 . . . AND ALTERED FOR THE UNIVERSITY OF
2100 C TASMANIA B6700 BY R.G. RICHARDSON (1978 BOTH ALGOL AND FORTRAN).
2200 C GRAVITY ONLY
2300 LOGICAL NEWPRB, NEWCP, REPLAC, NJCNST, FIRST, NF, NR
2400 INTEGER I, BUFCNT, IBUF, J, M1, N1, UH1, UV1, NP, NC, ND,
2500 . NCD, FM, M, AH, BH, AV, RV, NPROB, NCPT,
2600 . RPLAC, NCONST, CT, M0, DY11, NCP, CPC
2700 REAL UH, UV, XX, YY, ZZ, X1, X2, Y1, Y2, PI,
2800 . PIBY2, K, NUMBER, H1, H2, H3, A, B, C
2900 REAL SCALE(7), BBUF(5), CBUF(5), X(100), Y(100), Z(100),
3000 . GC(100), GZZC(100),
3100 . DENS(10), XA(450), YA(450), ZA(15), Q1, Q2, Q3
3200 INTEGER A1(7), B1(7), PPC(101), TITLE(80), NV(15)
3300 REAL UZ(100), W, V1, Z3(100), UZ1,
3400 . D3, TERM, SUM, Z1, Z2, RX1, RX2, R12, R1, R2, R11, R21,
3500 . EPSLNH, EPSLNV, SQ, CF, DX1, DY1, G1, P, ZPP,
3600 . COSG, COSB, BETA, GAMMA, DPSI, INTEGL, G, GZZ
3700 LOGICAL BA, BB, NDERIV, NANOM
3800 COMMON /INTGRL/ Q1(7), Q2(7), Q3(7), ND
3900 COMMON /WKSP/ W, P, PIBY2, DX1, DY1, PI, CF, SQ
4000 SCALE(5)=1.E5
4100 SCALE(4)=182.87984
4200 SCALE(6)=160934.3
4300 SCALE(1)=1.E2
4400 SCALE(2)=30.479973
4500 SCALE(3)=91.4399
4600 SCALE(7)=185318.2
4700 K=6.673E-8
4800
4900 C
5000 C*****
5100 C*****
5200 C SET OPTIONS HERE
5300 C NDERIV=.FALSE. FOR VERTICAL DERIVATIVE
5400 C NANOM=.FALSE. FOR SIMPLE ANOMALY
5500 C NDERIV=.FALSE.
5600 C NANOM=.FALSE.
5700 C*****
5800 C*****
5900 C
6000 A1(1)=6
6100 A1(2)=6
6200 A1(3)=6
6300 A1(4)=6
6400 A1(5)=3
6500 A1(6)=3
6600 A1(7)=3
6700 B1(1)=0
6800 B1(2)=0
6900 B1(3)=0
7000 B1(3)=0
7100 B1(4)=0
7200 B1(5)=3
7300 B1(6)=3
7400 B1(7)=3
7500 PI=3.1415926536
7600 PIBY2=PI/2.
7700 NUMBER=-57.2957795*7600./980.

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7800 NEWPRB=.TRUE.
7900 NEWCP=.TRUE.
8000 NUCNST=.TRUE.
8100 FIRST=.TRUE.
8200 999 CONTINUE
8300 C OLD REPEAT LABEL
8400 IF (.NOT. NEWCP) GO TO 14
8500 C READ COMPUTING POINTS
8600 WRITE(6,100)
8700 100 FORMAT(/37X,"D.S.I.R. GEOPHYSICS DIVISION"/38X,"THREE-DIME",
8800 "NSIONAL GRAVITY")
8900 READ(5,101) TITLE
9000 WRITE(6,101) TITLE
9100 101 FORMAT(1X,80A1)
9200 READ(5,102) UH1,UV1
9300 102 FORMAT(2I2)
9400 WRITE(6,103) UH1,UV1
9500 103 FORMAT(/" HORIZONTAL UNITS:" ,I3,6X,"VERTICAL UNITS:" ,I3)
9600 UH1=UH1+1
9700 UV1=UV1+1
9800 AH=A1(UH1)
9900 BH=B1(UH1)
10000 AV=A1(UV1)
10100 BV=B1(UV1)
10200 UH=SCALE(UH1)
10300 UV=SCALE(UV1)
10400 WRITE(6,104)
10500 104 FORMAT(/" COMPUTING POINTS:" /5X,"NO",7X,"X",9X,"Y",9X,"Z")
10600 I=0
10700 10 CONTINUE
10800 I=I+1
10900 READ(5,105) PPC(I),A,B,C
11000 105 FORMAT(I4,3F8.3)
11100 IF (PPC(I) .LT. 0) GO TO 11
11200 IF1TEM=AH+BH+4
11300 IF2TEM=AV+BV+4
11400 WRITE(6,106) PPC(I),IF1TEM,BH,A,B,IF2TEM,BV,C
11500 106 FORMAT(1X,I6,2F*,*,F*,*)
11600 A=A+1.E-6
11700 X(I)=A*UH
11800 Y(I)=B*UH
11900 Z(I)=-C*UV
12000 GO TO 10
12100 11 I=I-1
12200 NP=I
12300 C END READ COMPUTING POINTS
12400 14 CONTINUE
12500 IF (.NOT. NUCNST) GO TO 16
12600 C READ CONSTANTS
12700 READ(5,107) NCO
12800 107 FORMAT(I2)
12900 IF (NCO .LE. 0) STOP
13000 WRITE(6,108)
13100 108 FORMAT(1H1)
13200 C NEW PAGE
13300 WRITE(6,109)
13400 109 FORMAT(/" CONSTANTS:" /6X,"DENSITY")
13500 DO 15 N1=1,NCO
13600 READ(5,110) DENS(N1)
13700 110 FORMAT(F6.3)
13800 WRITE(6,111) DENS(N1)
13900 111 FORMAT(1X,F11.3)
14000 15 CONTINUE
14100 C END READ CONSTANTS
14200 16 CONTINUE
14300 C
14400 C
14500 C NEW BODY
14600 WRITE(6,112)
14700 112 FORMAT(1H1)
14800 C SKIP TO TOP OF FORM
14900 WRITE(6,113)
15000 113 FORMAT(" BODY:" /6X,"Z",5X,"NV",6X,5("X",8X,"Y",10X))
15100 READ(5,114) NC
15200 114 FORMAT(I3)
15300 I=NC-1
15400 ND=INT(I/2)
15500 IF (2*ND .EQ. I) GO TO 17
15600 WRITE(6,115)
15700 115 FORMAT(" SHOULD BE ODD NUMBER OF LAYERS")

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15800 STOP
15900 17 CONTINUE
16000 CT=0
16100 IF 2TEM=AV+BV+2
16200 FM=AH+BH+2
16300 DO 23 I=1,NC
16400 READ(5,116) A,M
16500 116 FORMAT(F8.2,I4)
16600 ZA(I)=-A*UV
16700 NV(I)=M
16800 WRITE(6,117) IF 2TEM,BV,A,M
16900 117 FORMAT(1H,F*.,I5)
17000 IF (M.EQ. 1) GOTO 22
17100 DY1I=0
17200 MO=CT+1
17300 CT=CT+M
17400 BUFCNT=0
17500 DO 20 J=MO,CT
17600 READ(5,118) B,C
17700 118 FORMAT(2F8.3)
17800 BUFCNT=BUFCNT+1
17900 BBUF(BUFCNT)=B
18000 CBUF(BUFCNT)=C
18100 XA(J)=B*UH
18200 YA(J)=C*UH
18300 DY1I=DY1I+1
18400 IF (MOD(DY1I,5) .NE. 0) GOTO 19
18500 WRITE(6,119) (FM,BH,BBUF(IBUF),FM,BH,CBUF(IBUF),IBUF=1,5)
18600 119 FORMAT(1H+,11X,10(2X,F*.,*))
18700 BUFCNT=0
18800 19 CONTINUE
18900 20 CONTINUE
19000 IF (BUFCNT .NE. 0) WRITE(6,120) (FM,BH,BBUF(IBUF),FM,BH,
19100 CBUF(IBUF),IBUF=1,BUFCNT)
19200 120 FORMAT(1H+,11X,10(2X,F*.,*))
19300 CT=CT+1
19400 XA(CT)=XA(MO)
19500 YA(CT)=YA(MO)
19600 22 CONTINUE
19700 C END READ COORDS FOR CONTOURS
19800 23 CONTINUE
19900 J=1
20000 DO 25 I=1,ND
20100 H3=ZA(J+1)
20200 H1=ZA(J)-H3
20300 H2=H3-ZA(J+2)
20400 H3=H1+H2
20500 IF (H1.LE. 0) GOTO 24
20600 H1=-H1
20700 H2=-H2
20800 H3=-H3
20900 24 CONTINUE
21000 Q1(I)=H3*(H2/H1-2)
21100 Q2(I)=-H3*H3*(H1/H2)
21200 Q3(I)=H3*(H1/H2-2)
21300 J=J+2
21400 C END I LOOP
21500 25 CONTINUE
21600 C
21700 C
21800 C WHAT TO DO WITH NEXT BODY
21900 READ(5,121) NPROB,NCPT,RPLAC,NCONST
22000 121 FORMAT(4I2)
22100 NEWPRB=NPROB .NE. 0
22200 NEWCP=NCPT .NE. 0
22300 REPLAC=RPLAC .NE. 0
22400 NUCNST=NCONST .NE. 0
22500 NF=.NOT. FIRST
22600 NR=.NOT. REPLAC
22700 C
22800 C CALCULATE ANOMALIES
22900 I=3
23000 IF (.FIRST) I=2
23100 NCP=INT(56/(1+I*NC))
23200 CPC=NCP
23300 EPSLNH=UH*1.E-6
23400 EPSLNV=UV*1.E-6
23500 XX=0
23600 YY=0
23700 ZZ=0

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23800 DO 80 M1=1,NP
23900 XX=XX-X(M1)
24000 YY=YY-Y(M1)
24100 ZZ=ZZ-Z(M1)
24200 CT=0
24300 DO 63 I=1,NC
24400 ZA(I)=ZA(I)+ZZ
24500 M=NV(I)
24600 IF (M.EQ. 1) GOTO 62
24700 MO=CT+1
24800 CT=MO+M
24900 DO 61 J=MO,CT
25000 XA(J)=XA(J)+XX
25100 YA(J)=YA(J)+YY
25200 61 CONTINUE
25300 62 CONTINUE
25400 C END I LOOP
25500 63 CONTINUE
25600 XX=X(M1)
25700 YY=Y(M1)
25800 ZZ=Z(M1)
25900 CT=0
26000 DO 74 I=1,NC
26100 M=NV(I)
26200 IF (M.NE. 1) GOTO 64
26300 UZ(I)=0
26400 Z3(I)=0
26500 GOTO 75
26600 C GOTO OLD NEW LABEL
26700 64 CONTINUE
26800 Z1=ZA(I)
26900 Z2=Z1*Z1
27000 MO=CT+1
27100 CT=CT+M
27200 X1=XA(MO)
27300 Y1=YA(MO)
27400 SQ=X1*X1+Y1*Y1
27500 RX1=SQRT(SQ)
27600 R1=SQRT(SQ+Z2)
27700 R1I=1.0/R1
27800 UZ1=0
27900 D3=0
28000 DO 73 J=MO,CT
28100 X2=XA(J+1)
28200 Y2=YA(J+1)
28300 SQ=X2*X2+Y2*Y2
28400 RX2=SQRT(SQ)
28500 R2=SQRT(SQ+Z2)
28600 R2I=1.0/R2
28700 DX1=X1-X2
28800 DY1=Y1-Y2
28900 R12=SQRT(DX1*DX1+DY1*DY1)
29000 P=(X1*Y2-X2*Y1)/R12
29100 SQ=P*P
29200 ZPP=Z2+SQ
29300 COSG=(DX1*X2+DY1*Y2)/(R12*RX2)
29400 COSB=(DX1*X1+DY1*Y1)/(R12*RX1)
29500 BA=ABS(P) .GT. EPSLMH
29600 C BA=BIG(P)
29700 IF (.NOT. BA) GOTO 72
29800 IF (NANOM) GOTO 81
29900 CF=Z1/SQRT(ZPP)
30000 BETA=ANGLE(X1,Y1,RX1,BA)
30100 GAMMA=ANGLE(X2,Y2,RX2,BA)
30200 DPSI=GAMMA-BETA
30300 SUM=DPSI+ANGLEE(COSG)-ANGLEE(COSB)
30400 UZ1=UZ1+SUM*F SIGN(P)
30500 81 CONTINUE
30600 IF (NDERIV) GOTO 72
30700 C NOT OERITAVE
30800 TERM=RX2*COSG*R2I
30900 CF=RX1+COSB*R1I
31000 G1=(CF-TERM)*P/ZPP
31100 SUM=CF/(R1*R1)-TERM/(R2*R2)
31200 D3=D3+(2.0*G1+P*SUM)/ZPP
31300 C IF (.NOT. BA) GOTO HERE
31400 72 CONTINUE
31500 X1=X2
31600 Y1=Y2
31700 RX1=RX2

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31800 R1=R2
31900 R11=R21
32000 73 CONTINUE
32100 C END J LOOP
32200 CT=CT+1
32300 UZ(I)=UZ1
32400 IF (.NOT. NDERIV) GOTO 75
32500 Z3(I)=D3*Z1
32600 75 CONTINUE
32700 C OLD NEW LABEL
32800 74 CONTINUE
32900 C END OF I LOOP
33000 IF (.NOT. NANOM) UZ1=-INTEGL(UZ)
33100 IF (.NOT. NDERIV) D3=-INTEGL(Z3)
33200 IF (CPC.NE. NCP) GOTO 76
33300 WRITE(6,129)
33400 129 FORMAT(1H1)
33500 WRITE(6,130)
33600 130 FORMAT(' COMPTG PT',8X,'G',7X,'GZZ')
33700 CPC=0
33800 76 CONTINUE
33900 CPC=CPC+1
34000 WRITE(6,131) PPC(M1)
34100 131 FORMAT(1H ,I7)
34200 DO 78 N1=1,NCO
34300 A=K*DENS(N1)
34400 G=-UZ1*A*1.E3
34500 GZZ=-D3*A*1.E15
34600 WRITE(6,132) G,GZZ
34700 132 FORMAT(1H+,11X,F9.2,F10.1)
34800 IF (.NOT. NF .OR. N1.NE. NCO) GOTO 77
34900 GC(M1)=G
35000 GZZTEM=GZZC(M1)+GZZ
35100 WRITE(6,133) GC(M1),GZZTEM
35150 133 FORMAT(12X,F9.2,F10.1)
35200 77 CONTINUE
35300 WRITE(6,134)
35400 134 FORMAT(/)
35500 C END N1 LOOP
35600 78 CONTINUE
35700 IF (.NOT. FIRST) GOTO 79
35800 GC(M1)=G
35900 GZZC(M1)=GZZ
36000 GOTO 80
36100 79 CONTINUE
36200 IF (.NOT. NR) GOTO 90
36300 GC(M1)=GC(M1)+G
36400 GZZC(M1)=GZZC(M1)+GZZ
36500 80 CONTINUE
36600 C END M1 LOOP
36700 C END ANOMALIES
36800 FIRST=NEWPRB .OR. NFWCP .OR. (FIRST .AND. REPLAC)
36900 GOTO 999
37000 CGOTO OLD REPEAT LABEL
37100 END
37200 C END MAIN PROGRAM
37300 C
37400 REAL FUNCTION INTEGL(A)
37500 DIMENSION A(2)
37600 INTEGER K,J
37700 REAL I,W
37800 COMMON /INTGRL/ Q1(7),Q2(7),Q3(7),NC
37900 I=0
38000 K=1
38100 J=1
38200 10 CONTINUE
38300 W=Q1(K)*A(J)
38400 J=J+1
38500 W=W+Q2(K)*A(J)
38600 J=J+1
38700 I=I+W+Q3(K)*A(J)
38800 K=K+1
38900 IF (K=ND.LT. 1) GOTO 10
39000 INTEGL=I/6.
39100 RETURN
39200 END
39300 REAL FUNCTION ANGLE(XA,YA,R,B)
39400 LOGICAL B
39500 COMMON /WKSP/W,P,PIRY2,DX1,DY1,PI,CF,SQ
39600 W=ABS(P)/R

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39700      IF (W .GE. 1.) GOTO 10
39800      W=ARSIN(W)
39900      GOTO 20
40000 10    W=PI*BY2
40100 20    CONTINUE
40200      B=(XA*DX1+YA*DY1) .LT. 0.0
40300      IF(B) W=PI-W
40400      ANGLE=W
40500      RETURN
40600      END
40700      REAL FUNCTION ANGLEF(CCOS)
40800      COMMON/WKSP/W,P,PI*BY2,DX1,DY1,PI,CF,SQ
40900      W=CF*CCOS
41000      IF (ABS(W) .LT. 1.) GOTO 10
41100      ANGLEF=FSIGN(W)*PI*BY2
41200      RETURN
41300 10    ANGLEF=ARSIN(W)
41400      RETURN
41500      END
41600      REAL FUNCTION FSIGN(A)
41700      IF (A .EQ. 0.) GOTO 10
41800      IF (A .GT. 0.0) GOTO 20
41900      FSIGN=-1.
42000      RETURN
42100 10    FSIGN=0.
42200      RETURN
42300 20    FSIGN=1.
42400      RETURN
42500      END

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