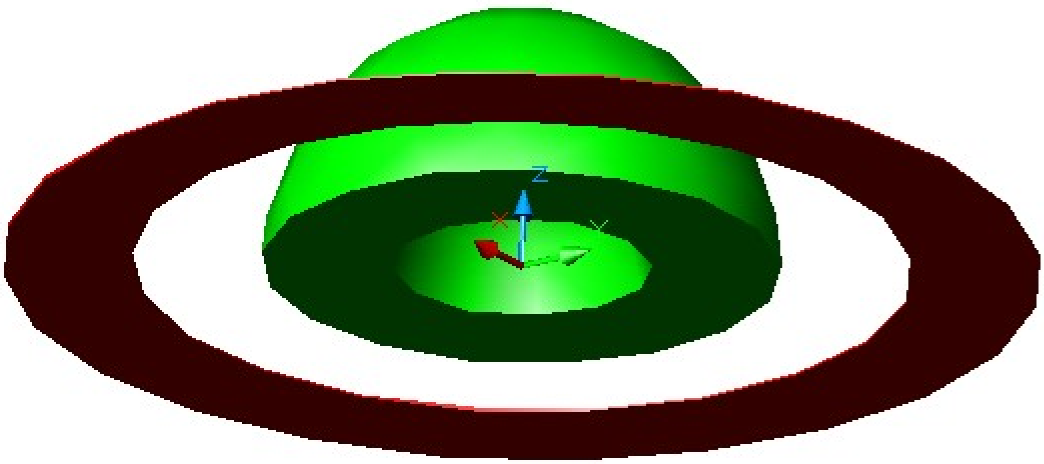
The Theory of Hollow Worlds



A Study of the Natural Mechanics of the Theory of Hollow Worlds

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Including a Brief Look at the Spaceship Moon Hypothesis

Introduction

The theory of the hollow worlds has been around for ages. The concept has taken many forms. All of the forms have been coached in a localized religious or social fantasy by men who had other interests than natural philosophy.

Included in the theory of hollow worlds is the idea of interconnecting cavities within the body of the Earth and presumably other worlds as well. These imaginings have also been presented as social and religious fantasies having nothing to do with reality.

This study seeks to alleviate the foregoing shortcomings by presenting real data that may be verified by means available to the majority of people at the time of this writing. The most exotic component is the modern PC. 70 years ago it was not available. In another 70 years it may no longer be available. However, it is readily available now. The computer programs have been written as simple number crunching processes written by the programmer, (myself), as a single minded proxy capable of doing millions of mathematical calculations linked together with decision making instructive code. There will be five basic components included in this study. This is an ideal study. The modeling density is assumed to be uniform, which would never occur in the real world.

The first part is the situation of the “Thin Ring” in space. This will be a gravitational study based on Isaac Newton’s law of universal attraction of mass. The data will be acquired by a computer model of the thin ring one unit thick. From a given point the sum force of gravitational attraction will be calculated both with respect to the center and with respect to right angles to the center. The latter will represent one half of the compressive force. The process will utilize three nested conditional WHILE loops. The first WHILE loop will advance the distance of the observer from the center by one unit per loop. The second WHILE loop will advance the distance from the observer by one unit per loop. The third WHILE loop will advance the scan angle along the circumference of the scan by one unit by one unit per loop. The result will be an evaluation of each and every cubic unit within the thin ring. The x-components and the y-components will then be summed up.

The second part will be like the first part, except that it shall be for a three dimensional sphere. This is the ideal hollow world.

The third part shall evaluate the possibility of interconnecting cavities within the shell of the hollow world. This will be done by experimentation and computer processing of the results.

The fourth part is a look at the internal sheer stresses due to the revolutions of the hollow world about its polar axis.

The fifth part imagines that the interior of a hollow world contains an atmosphere that is not observable at the outer surface.

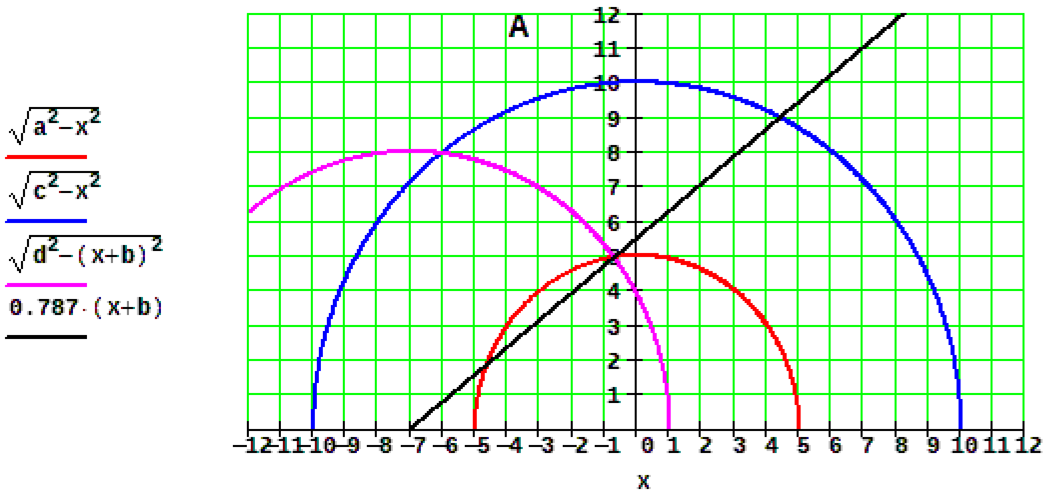
In preparing this study I have used certain computer software. At the time of this writing some of the software is considered “obsolete.” Personally, I have no idea what is meant by the term. In truth, the people who use the term probably have no idea what they mean by the term. They are only parroting ad copy from the software industry. That said, here are the software that I used in this study.

1. “Libre Office” suite: I used the “writer” for the main document as *.odf. I used the “export as pdf” for the *.pdf format.
2. “Liberty BASIC v.4.03”: This was the programming language that I used in writing the *.bas programs that I used as a proxy to reduce the tedium and avoid transcription errors.
3. “SciDaVis”: This is a number crunching graphic utility for creating graphs from raw data. [Sci]entific [Da]ta [Vis]ualization.
4. “StudyWorks5”: This is a Mathematical Word Processor that I used to create the proper imagery for the mathematical presentations. It is essentially a programming language and word processor combined.
5. “MS Notepad”: This is the “WINDOWS” ASCII formatted script used in creating the *.txt files.
6. “MS Paint”: This was used to create the graphic imagery.
7. “AutoCad2000”: For example; This was used to create the cover image.
8. “Windows XP”: Some of the software required an older OS.
9. “Windows 8.1”: Another computer and OS.
10. “Windows 10”: Main computer for project.

Gravitational Attraction of a Thin Ring

Here is the mathematical intercept for the inner radius.

[20240211B] $a := 5$ $b := 7$ $c := 10$ $d := 8$



$$(x+b)^2 + y^2 = d^2 \qquad x^2 + y^2 = a^2$$

$$y^2 = d^2 - (x+b)^2 \qquad y^2 = a^2 - x^2 \qquad y^2 = y^2$$

$$d^2 - (x+b)^2 = a^2 - x^2$$

$$d^2 - x^2 - 2\cdot x\cdot b - b^2 = a^2 - x^2$$

$$d^2 - 2\cdot x\cdot b - b^2 - x^2 = a^2 - x^2 \qquad -x^2 = -x^2$$

$$d^2 - 2\cdot x\cdot b - b^2 = a^2$$

$$d^2 - a^2 - b^2 = 2\cdot x\cdot b \qquad \frac{d^2 - a^2 - b^2}{2\cdot b} = x \qquad y = \sqrt{a^2 - x^2}$$

$$q = \operatorname{acos}\left(\frac{x+b}{d}\right) \qquad m = \frac{y}{x+b}$$

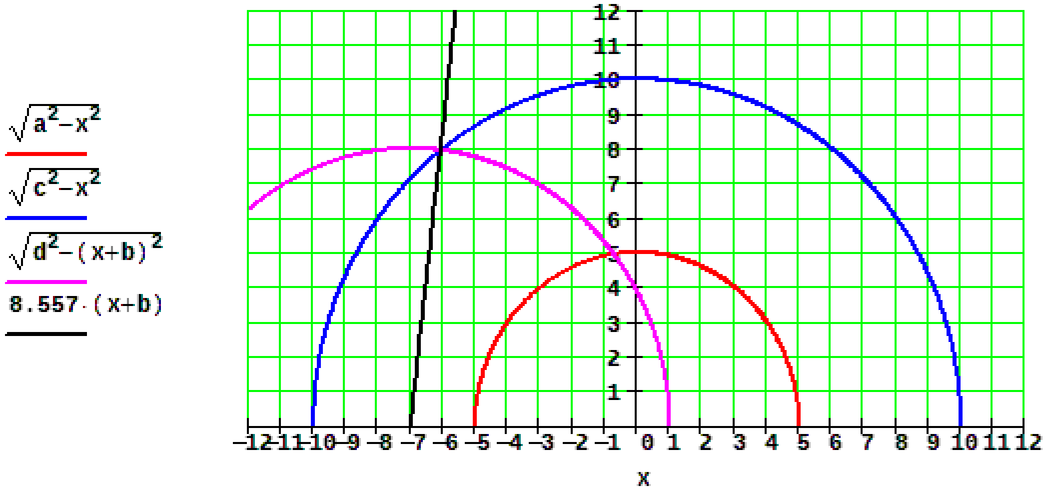
$$xlo := \frac{d^2 - a^2 - b^2}{2\cdot b} \qquad xlo = -0.714 \qquad qlo := \operatorname{acos}\left(\frac{xlo+b}{d}\right)$$

$$ylo := \sqrt{a^2 - xlo^2} \qquad ylo = 4.949 \qquad qlo = 0.667$$

$$mlo := \frac{ylo}{xlo+b} \qquad mlo = 0.787$$

Here is the mathematical intercept for the outer radius.

[20240211C] $a := 5$ $b := 7$ $c := 10$ $d := 8$



$(x+b)^2 + y^2 = d^2$ $\quad x^2 + y^2 = c^2$

$y^2 = d^2 - (x+b)^2$ $\quad y^2 = c^2 - x^2$ $\quad y^2 = y^2$

$d^2 - (x+b)^2 = c^2 - x^2$

$d^2 - x^2 - 2 \cdot x \cdot b - b^2 = c^2 - x^2$

$d^2 - 2 \cdot x \cdot b - b^2 - x^2 = c^2 - x^2$ $\quad -x^2 = -x^2$

$d^2 - 2 \cdot x \cdot b - b^2 = c^2$

$d^2 - c^2 - b^2 = 2 \cdot x \cdot b$ $\quad \frac{d^2 - c^2 - b^2}{2 \cdot b} = x$ $\quad y = \sqrt{c^2 - x^2}$

$q = \operatorname{acos}\left(\frac{x+b}{d}\right)$ $\quad m = \frac{y}{x+b}$

$xhi := \frac{d^2 - c^2 - b^2}{2 \cdot b}$ $\quad xhi = -6.071$ $\quad qhi := \operatorname{acos}\left(\frac{xhi+b}{d}\right)$

$yhi := \sqrt{c^2 - xhi^2}$ $\quad yhi = 7.946$ $\quad qhi = 1.454$

$mhi := \frac{yhi}{xhi+b}$ $\quad mhi = 8.557$

To begin this study of the thin ring, let us first consider the foregoing mathematical models and the intercept equations. Using these intercepts will make the programs run faster by telling the computer when to begin a scan of angle [q] and when to end a scan of angle [q].

Due to computer and program issues there will be three programs required. Each program is virtually identical. However, certain limiting parameters have been adjusted in order to allow for the cases where no intercept is possible.

There is a line that initiates the middle WHILE loop at [d = 1.0001]. It was originally at [d = 1], but the program would bind up. This was probably due to the risks involved with a precise [1] or a precise[0]. Sometimes an insignificant offset [i.e. +0.0001] is required.

Here is the program as written for the interior space of the thin ring.

```
REM LIBERTY BASIC v4.03
REM ThinRing01.bas

REM This program is only capable of gravitationally evaluating
REM for a point within the interior space of a thin ring.

REM Define Variables (VAR):
REM VAR   a = inner radius fom center.
REM VAR   b = center of scan from center.
REM VAR   c = outer radius from center = 100 units.
REM VAR   d = secondary radius of scan.
REM VAR   p = pi = 3.14159.
REM VAR xlo = x-component of intercept of VAR a and VAR b.
REM VAR ylo = y-component of intercept of VAR a and VAR b.
REM VAR mlo = slope of VAR d.
REM VAR qlo = angle in radians between intercept of
REM           Var a and VAR b with respect to center of VAR b.
REM VAR xhi = x-component of intercept of VAR c and VAR b.
REM VAR yhi = y-component of intercept of VAR c and VAR b.
REM VAR mhi = slope of VAR d.
REM VAR qhi = angle in radians between intercept of
REM           Var c and VAR b with respect to center of VAR b.
REM VAR qin = increment of scanning angle q neccessary for one
REM           unit along circumference in radians.
REM VAR qsc = Angle of innnermost scan in radians.
REM VAR xgf = x-component of gravitational force.
REM VAR ygf = y-component of gravitational force.
REM VAR xsf = x-component of Sum of gravitational force.
REM VAR xsf = y-component of Sum of gravitational force.
REM VAR xst = x-component of Sub-Total of gravitational force.
REM VAR yst = y-component of Sub-Total of gravitational force.
REM VAR xtf = x-component of Total gravitational force.
REM VAR ytf = y-component of Total gravitational force.
REM VAR ngf = Normal gravitational force for hemisphere.
REM VAR qtg = Angle of gravational vector.
```

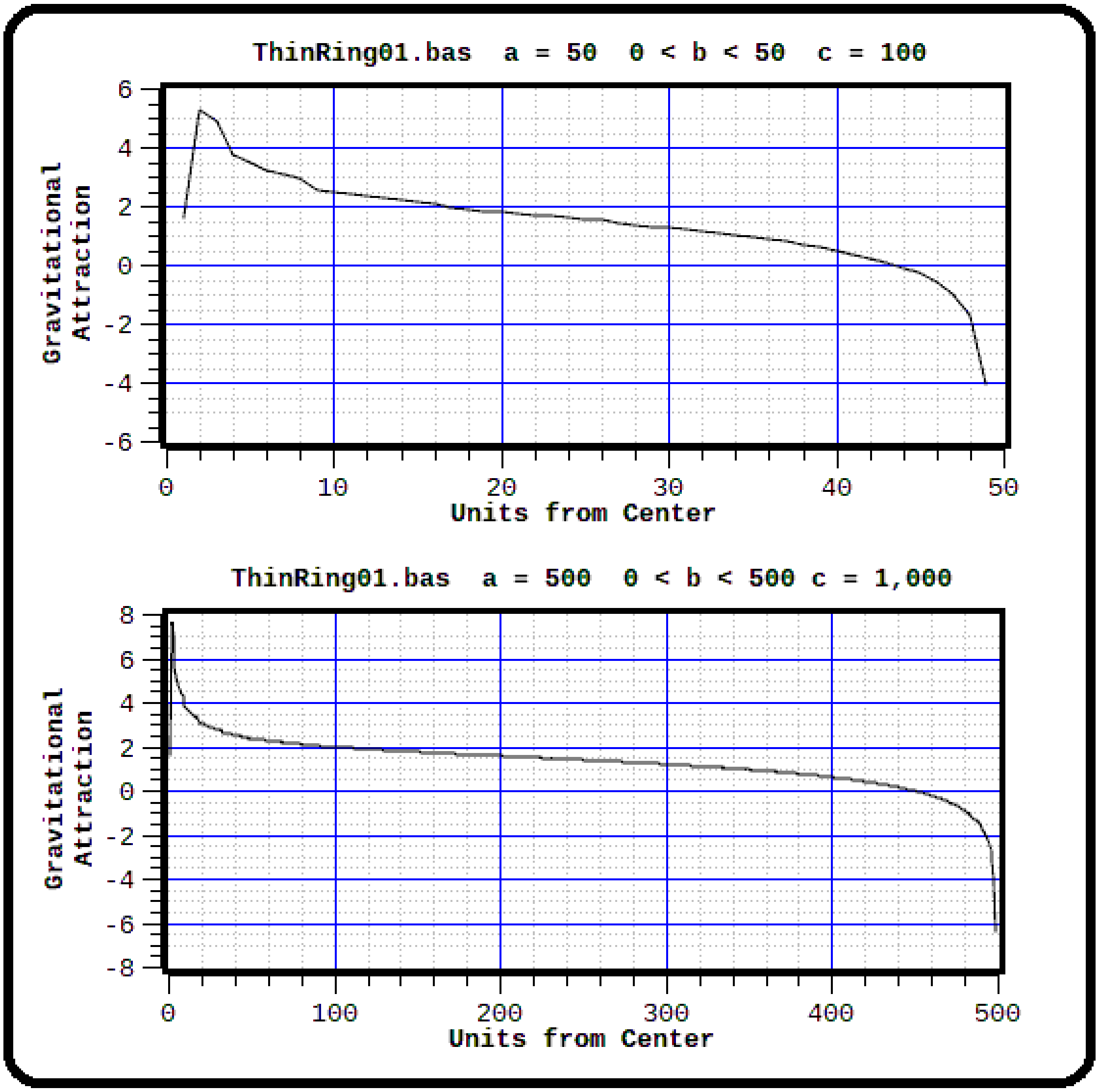
```
   REM Load constants:
   LET   p = 3.14159

   REM Enter voluntary data:
 INPUT "Enter outer radius (c)    : "; c
 INPUT "Enter inner radius (a) a<c: "; a

   REM Establish outermost loop.
   LET xtg = 0
   LET ytg = 0
   LET b = 1
   WHILE b < a

   REM Initiate WHILE loop for VAR b radius:
   LET d = 1.0001
   LET xtf = 0
   LET ytf = 0
 WHILE d <= (b + c)

   REM Calculate parameters for scan next WHILE loop:

   LET qin = 1/d

    IF d >= (a + b) AND d <= (c + b)  THEN
   LET xlo = (a - d)
   LET ylo = 0
   LET mlo = 0
   LET qlo = 0
END IF

    IF d < (a + b) AND d > (a - b) THEN
   LET xlo = (d^2 - a^2 - b^2)/(2 * b)
   LET ylo = (a^2 - xlo^2)^(1/2)
   LET mlo = ylo/(xlo + b)
   LET qlo = acs((xlo + b)/d)
END IF

    IF d > (a - b) AND d < (c - b) THEN
   LET xhi = (c - d)
   LET yhi = 0
   LET mhi = 0
   LET qhi = p
END IF

    IF d > (c - b) THEN
   LET xhi = (d^2 - c^2 - b^2)/(2 * b)
   LET yhi = (c^2 - xhi^2)^(1/2)
   LET mhi = yhi/(xhi + b)
   LET qhi = acs((xhi + b)/d)
END IF

   REM Establish inner WHILE loop:
   LET qsc = qlo
   LET xsf = 0
   LET ysf = 0
```

```
  WHILE qsc <= qhi

    REM Do innermost calculations:
    LET xgf =  (cos(qsc))/(d^2)
    LET ygf =  (sin(qsc))/(d^2)

    REM Close out inner WHILE loop:
    LET xsf = xsf + xgf
    LET ysf = ysf + ygf
    LET qsc = qsc + qin
    LET xst = xsf
    LET yst = ysf
  WEND

    REM Add subtotal gravitational forces
    LET xtf = xtf + xst
    LET ytf = ytf + yst

    REM Close out WHILE loop for VAR b radius:
    LET d = d + 1
   WEND


   LET qtg = acs(xtf/((xtf^2 + ytf^2)^0.5)) * (180/p)
   LET ngf = (xtf^2 + ytf^2)^0.5

  PRINT using("####",b);
  PRINT using("#####.####",xtf);
  PRINT using("#####.####",ytf);
  PRINT using("#####.####",ngf);
  PRINT using("#####.####",qtg)

    REM Close out first WHILE loop.
    LET b = b + 1
   WEND

    REM End program:
    END
```

Next is a sample run from the preceding program along with the applicable graphs. There are two runs laid side by side. The left run is a “quickie” run of a few seconds for an outer radius of 100 units and an inner radius of 50 units. The right run is similar to the left run except that it is more detailed. The entered outer radius was 1,000 units and the entered inner radius was 500 units. The latter required about 2 hours to run. Placing them side by side will permit the discounting of program issues.

Quick Run					Detailed Run				
Enter outer radius (c) : 100					Enter outer radius (c) : 1000				
Enter inner radius (a) a<c: 50					Enter inner radius (a) a<c: 500				
d	xtf	ytf	ngf	qtg	d	xtf	ytf	ngf	qtg
1	1.6184	1.3867	2.1312	40.5906	10	3.8234	1.9531	4.2933	27.0587
2	5.2649	5.7028	7.7615	47.2866	20	3.0282	1.6369	3.4423	28.3937
3	4.8506	4.0712	6.3327	40.0075	30	2.7457	1.5596	3.1577	29.5968
4	3.7411	2.4500	4.4719	33.2203	40	2.5156	1.5089	2.9334	30.9565
5	3.4663	2.2135	4.1127	32.5609	50	2.3403	1.4785	2.7682	32.2841
6	3.2182	2.0404	3.8105	32.3749	60	2.2514	1.4685	2.6880	33.1154
7	3.0470	1.9451	3.6150	32.5528	70	2.1469	1.4578	2.5950	34.1767
8	2.9527	1.9069	3.5149	32.8541	80	2.0842	1.4553	2.5421	34.9251
9	2.5623	1.7115	3.0813	33.7418	90	2.0360	1.4562	2.5032	35.5736
10	2.4972	1.6969	3.0192	34.1974	100	1.9631	1.4545	2.4433	36.5353
11	2.4265	1.6820	2.9524	34.7290	110	1.9174	1.4576	2.4085	37.2431
12	2.3501	1.6655	2.8804	35.3260	120	1.8602	1.4603	2.3649	38.1325
13	2.2587	1.6455	2.7945	36.0737	130	1.8198	1.4659	2.3368	38.8520
14	2.1947	1.6386	2.7389	36.7460	140	1.7854	1.4732	2.3147	39.5274
15	2.1420	1.6379	2.6964	37.4036	150	1.7371	1.4798	2.2820	40.4263
16	2.0996	1.6426	2.6658	38.0381	160	1.7015	1.4888	2.2609	41.1845
17	1.9061	1.5965	2.4863	39.9490	170	1.6696	1.4991	2.2438	41.9215
18	1.8713	1.6062	2.4661	40.6399	180	1.6253	1.5093	2.2180	42.8807
19	1.8298	1.6152	2.4407	41.4353	190	1.5920	1.5216	2.2022	43.7041
20	1.7763	1.6222	2.4056	42.4029	200	1.5606	1.5352	2.1891	44.5302
21	1.7368	1.6344	2.3849	43.2597	210	1.5190	1.5491	2.1696	45.5606
22	1.6787	1.6425	2.3486	44.3769	220	1.4853	1.5649	2.1576	46.4952
23	1.6373	1.6580	2.3302	45.3592	230	1.4530	1.5822	2.1482	47.4373
24	1.5917	1.6734	2.3095	46.4330	240	1.4120	1.6002	2.1342	48.5748
25	1.5444	1.6910	2.2901	47.5953	250	1.3786	1.6204	2.1275	49.6105
26	1.5045	1.7127	2.2797	48.7033	260	1.3424	1.6420	2.1209	50.7322
27	1.3784	1.7129	2.1986	51.1757	270	1.2996	1.6649	2.1121	52.0251
28	1.3347	1.7379	2.1913	52.4763	280	1.2633	1.6902	2.1102	53.2254
29	1.2903	1.7651	2.1864	53.8322	290	1.2244	1.7175	2.1092	54.5157
30	1.2409	1.7941	2.1814	55.3301	300	1.1847	1.7470	2.1108	55.8568
31	1.1847	1.8242	2.1751	56.9988	310	1.1368	1.7785	2.1108	57.4140
32	1.1316	1.8583	2.1757	58.6615	320	1.0915	1.8130	2.1162	58.9518
33	1.0679	1.8933	2.1737	60.5758	330	1.0454	1.8507	2.1255	60.5383
34	0.9973	1.9332	2.1752	62.7122	340	0.9905	1.8913	2.1349	62.3586
35	0.9367	1.9785	2.1890	64.6651	350	0.9380	1.9361	2.1513	64.1501
36	0.8703	2.0278	2.2067	66.7705	360	0.8809	1.9851	2.1718	66.0703
37	0.7955	2.0830	2.2297	69.0989	370	0.8196	2.0392	2.1978	68.1035
38	0.6675	2.1334	2.2354	72.6258	380	0.7486	2.0989	2.2284	70.3695
39	0.5734	2.2013	2.2747	75.3987	390	0.6755	2.1656	2.2685	72.6772
40	0.4788	2.2779	2.3277	78.1295	400	0.5934	2.2404	2.3177	75.1643
41	0.3624	2.3659	2.3935	81.2904	410	0.5034	2.3253	2.3792	77.7836
42	0.2294	2.4656	2.4762	84.6844	420	0.3962	2.4222	2.4544	80.7101
43	0.0921	2.5812	2.5829	87.9558	430	0.2772	2.5349	2.5500	83.7595
44	-0.1183	2.7177	2.7203	92.4915	440	0.1383	2.6683	2.6719	87.0324
45	-0.2927	2.8900	2.9048	95.7838	450	-0.0326	2.8298	2.8299	90.6604
46	-0.5898	3.1077	3.1631	100.7459	460	-0.2422	3.0326	3.0422	94.5668
47	-1.0072	3.3975	3.5437	106.5123	470	-0.5204	3.3009	3.3416	98.9601
48	-1.7329	3.8283	4.2022	114.3541	480	-0.9298	3.6895	3.8049	104.1447
49	-4.0798	4.5859	6.1381	131.6578	490	-1.6488	4.3784	4.6786	110.6352

Here is a graphic illustration of the preceding computer runs. The preceding detailed run has been cropped where the rows are all multiples of 10. This has been done for convenience. However, the lower graph has not been so cropped.



Observe how the gravitational attraction appears to seek to spike towards the center of the thin ring. Observe how just before the inner radius the gravitational attraction goes into a negative spike. Observe how the gravitational attraction towards the center appears to increase with the proximity to the center.

Here is the second program for calculating the gravitational parameters for the thin ring. This program works for the area between the inner radius and the outer radius. The principle difference is the allowance for the situations where there is no low intercept to begin a scan or a high intercept to end a scan.

```
  REM LIBERTY BASIC v4.03
  REM ThinRing02.bas

  REM This program is restricted to the middle disk area
  REM of the thin ring.

  REM Define Variables (VAR):
  REM VAR   a = inner radius fom center.
  REM VAR   b = center of scan from center.
  REM VAR   c = outer radius from center = 100 units.
  REM VAR   d = secondary radius of scan.
  REM VAR   p = pi = 3.14159.
  REM VAR xlo = x-component of intercept of VAR a and VAR b.
  REM VAR ylo = y-component of intercept of VAR a and VAR b.
  REM VAR mlo = slope of VAR d.
  REM VAR qlo = angle in radians between intercept of
  REM           Var a and VAR b with respect to center of VAR b.
  REM VAR xhi = x-component of intercept of VAR c and VAR b.
  REM VAR yhi = y-component of intercept of VAR c and VAR b.
  REM VAR mhi = slope of VAR d.
  REM VAR qhi = angle in radians between intercept of
  REM           Var c and VAR b with respect to center of VAR b.
  REM VAR qin = increment of scanning angle q neccessary for one
  REM           unit along circumference in radians.
  REM VAR qsc = Angle of innnermost scan in radians.
  REM VAR xgf = x-component of gravitational force.
  REM VAR ygf = y-component of gravitational force.
  REM VAR xsf = x-component of Sum of gravitational force.
  REM VAR xsf = y-component of Sum of gravitational force.
  REM VAR xst = x-component of Sub-Total of gravitational force.
  REM VAR yst = y-component of Sub-Total of gravitational force.
  REM VAR xtf = x-component of Total gravitational force.
  REM VAR ytf = y-component of Total gravitational force.
  REM VAR ngf = Normal gravitational force for hemisphere.
  REM VAR qtg = Angle of gravational vector.                 '


  REM Load constants:
  LET   p = 3.14159

  REM Enter voluntary data:
INPUT "Enter outer radius (c)    : "; c
INPUT "Enter inner radius (a) a<c: "; a

  REM Establish outermost loop.
  LET xtg = 0
  LET ytg = 0
```

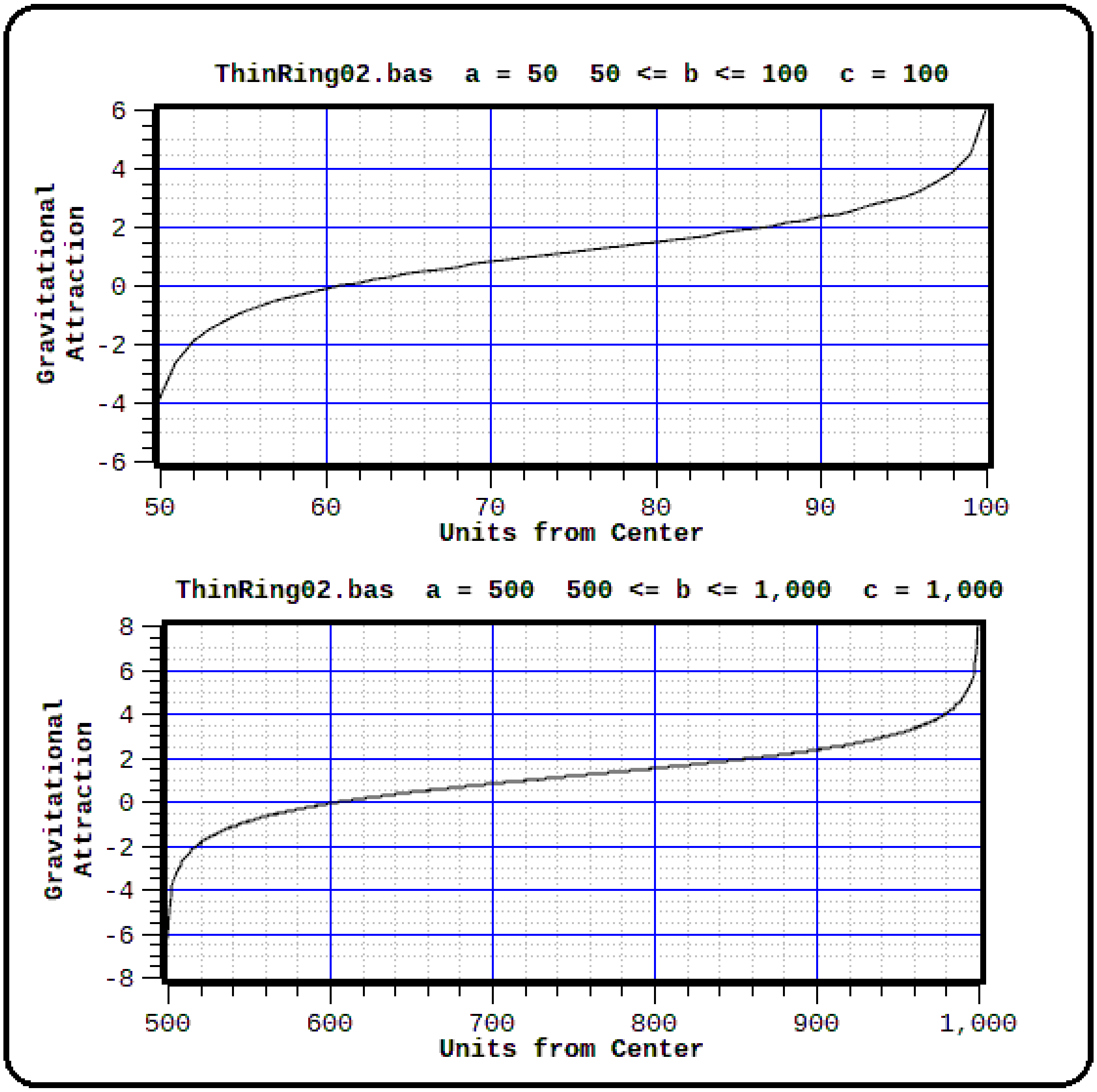
```
   LET b = a
   WHILE b <= c

   REM Initiate WHILE loop for VAR b radius:
   LET d = 1.0001
   LET xtf = 0
   LET ytf = 0
  WHILE d <= (b + c)

   REM Calculate parameters for scan next WHILE loop:

   LET qin = 1/d

    IF d < (b - a) OR d > (b + a)  THEN
   LET xlo = (a - d)
   LET ylo = 0
   LET mlo = 0
   LET qlo = 0
END IF

    IF d > (b - a) AND d < (b + a) THEN
   LET xlo = (d^2 - a^2 - b^2)/(2 * b)
   LET ylo = (a^2 - xlo^2)^(1/2)
   LET mlo = ylo/(xlo + b)
   LET qlo = acs((xlo + b)/d)
END IF

    IF d <= (c - b) THEN
   LET xhi = (c - d)
   LET yhi = 0
   LET mhi = 0
   LET qhi = p
END IF

    IF d > (c - b) THEN
   LET xhi = (d^2 - c^2 - b^2)/(2 * b)
   LET yhi = (c^2 - xhi^2)^(1/2)
   LET mhi = yhi/(xhi + b)
   LET qhi = acs((xhi + b)/d)
END IF

   REM Establish inner WHILE loop:
   LET qsc = qlo
   LET xsf = 0
   LET ysf = 0
  WHILE qsc <= qhi

   REM Do innermost calculations:
   LET xgf =  (cos(qsc))/(d^2)
   LET ygf =  (sin(qsc))/(d^2)

   REM Close out inner WHILE loop:
   LET xsf = xsf + xgf
   LET ysf = ysf + ygf
   LET qsc = qsc + qin
```

```
  LET xst = xsf
  LET yst = ysf
WEND

  REM Add subtotal gravitational forces
  LET xtf = xtf + xst
  LET ytf = ytf + yst

  REM Close out WHILE loop for VAR b radius:
  LET d = d + 1
 WEND


 LET qtg = acs(xtf/((xtf^2 + ytf^2)^0.5)) * (180/p)
 LET ngf = (xtf^2 + ytf^2)^0.5

PRINT using("####",b);
PRINT using("#####.####",xtf);
PRINT using("#####.####",ytf);
PRINT using("#####.####",ngf);
PRINT using("#####.####",qtg)

  REM Close out first WHILE loop.
  LET b = b + 1
 WEND

  REM End program:
  END
```

Here are a pair of sample runs for the preceding program for the intermediate level of the thin ring. The entered parameters are the same as the preceding innermost case. The one on the left is “as-is” and the has been cropped to multiples of ten. Because these are similar cases, the latter has been scaled by a factor of 10 to compare with the former case. Observe that the detailed run has 10 times the radius and 100 times the volume of the quick run.

Quick Run					**Detailed Run**				
Enter outer radius (c) : 100					**Enter outer radius (c) : 1000**				
Enter inner radius (a) a<c: 50					**Enter inner radius (a) a<c: 500**				
d	**xtf**	**ytf**	**ngf**	**qtg**	**d**	**xtf**	**ytf**	**ngf**	**qtg**
50	**-3.8436**	**6.7419**	**7.7606**	**119.6883**	**500**	**-6.1925**	**9.0564**	**10.9711**	**124.3633**
51	**-2.6478**	**7.6514**	**8.0966**	**109.0884**	**510**	**-2.6601**	**11.9320**	**12.2249**	**102.5681**
52	**-1.9115**	**8.1033**	**8.3257**	**103.2732**	**520**	**-1.9221**	**12.5436**	**12.6900**	**98.7119**
53	**-1.5117**	**8.3865**	**8.5216**	**100.2183**	**530**	**-1.4832**	**12.8820**	**12.9671**	**96.5679**
54	**-1.2154**	**8.5827**	**8.6683**	**98.0603**	**540**	**-1.1678**	**13.1067**	**13.1587**	**95.0915**
55	**-0.9536**	**8.7268**	**8.7787**	**96.2361**	**550**	**-0.9174**	**13.2692**	**13.3009**	**93.9552**
56	**-0.7275**	**8.8382**	**8.8681**	**94.7058**	**560**	**-0.7116**	**13.3922**	**13.4111**	**93.0417**
57	**-0.5436**	**8.9258**	**8.9423**	**93.4849**	**570**	**-0.5343**	**13.4882**	**13.4987**	**92.2687**
58	**-0.3846**	**8.9949**	**9.0032**	**92.4484**	**580**	**-0.3791**	**13.5642**	**13.5695**	**91.6009**
59	**-0.2525**	**9.0504**	**9.0539**	**91.5984**	**590**	**-0.2405**	**13.6253**	**13.6274**	**91.0112**
60	**-0.1262**	**9.0965**	**9.0974**	**90.7948**	**600**	**-0.1146**	**13.6744**	**13.6749**	**90.4802**
61	**-0.0119**	**9.1329**	**9.1330**	**90.0745**	**610**	**0.0006**	**13.7139**	**13.7139**	**89.9975**
62	**0.0944**	**9.1618**	**9.1623**	**89.4099**	**620**	**0.1077**	**13.7455**	**13.7459**	**89.5510**
63	**0.1971**	**9.1840**	**9.1862**	**88.7706**	**630**	**0.2079**	**13.7703**	**13.7719**	**89.1351**
64	**0.2926**	**9.2014**	**9.2060**	**88.1790**	**640**	**0.3021**	**13.7893**	**13.7926**	**88.7451**
65	**0.3830**	**9.2137**	**9.2217**	**87.6200**	**650**	**0.3914**	**13.8032**	**13.8088**	**88.3760**
66	**0.4662**	**9.2223**	**9.2340**	**87.1059**	**660**	**0.4765**	**13.8128**	**13.8210**	**88.0245**
67	**0.5463**	**9.2272**	**9.2434**	**86.6119**	**670**	**0.5582**	**13.8182**	**13.8294**	**87.6867**
68	**0.6264**	**9.2277**	**9.2489**	**86.1166**	**680**	**0.6368**	**13.8200**	**13.8346**	**87.3616**
69	**0.7032**	**9.2246**	**9.2513**	**85.6405**	**690**	**0.7130**	**13.8184**	**13.8367**	**87.0464**
70	**0.7805**	**9.2186**	**9.2516**	**85.1608**	**700**	**0.7872**	**13.8136**	**13.8360**	**86.7386**
71	**0.8547**	**9.2115**	**9.2511**	**84.6989**	**710**	**0.8596**	**13.8059**	**13.8326**	**86.4371**
72	**0.9255**	**9.1985**	**9.2449**	**84.2548**	**720**	**0.9307**	**13.7952**	**13.8266**	**86.1405**
73	**0.9951**	**9.1856**	**9.2393**	**83.8175**	**730**	**1.0007**	**13.7818**	**13.8181**	**85.8471**
74	**1.0641**	**9.1683**	**9.2298**	**83.3795**	**740**	**1.0701**	**13.7657**	**13.8073**	**85.5552**
75	**1.1309**	**9.1523**	**9.2219**	**82.9560**	**750**	**1.1387**	**13.7471**	**13.7942**	**85.2648**
76	**1.2014**	**9.1267**	**9.2055**	**82.5009**	**760**	**1.2074**	**13.7255**	**13.7785**	**84.9730**
77	**1.2687**	**9.1047**	**9.1927**	**82.0671**	**770**	**1.2759**	**13.7014**	**13.7606**	**84.6798**
78	**1.3376**	**9.0756**	**9.1736**	**81.6158**	**780**	**1.3449**	**13.6743**	**13.7403**	**84.3831**
79	**1.4094**	**9.0438**	**9.1529**	**81.1422**	**790**	**1.4143**	**13.6445**	**13.7176**	**84.0825**
80	**1.4771**	**9.0143**	**9.1346**	**80.6942**	**800**	**1.4847**	**13.6116**	**13.6924**	**83.7751**
81	**1.5491**	**8.9776**	**9.1103**	**80.2100**	**810**	**1.5563**	**13.5756**	**13.6645**	**83.4601**
82	**1.6221**	**8.9349**	**9.0810**	**79.7103**	**820**	**1.6295**	**13.5360**	**13.6338**	**83.1358**
83	**1.6959**	**8.8936**	**9.0539**	**79.2042**	**830**	**1.7044**	**13.4930**	**13.6002**	**82.8006**
84	**1.7746**	**8.8438**	**9.0201**	**78.6540**	**840**	**1.7820**	**13.4456**	**13.5632**	**82.4504**
85	**1.8539**	**8.7940**	**8.9873**	**78.0956**	**850**	**1.8622**	**13.3940**	**13.5229**	**82.0850**
86	**1.9340**	**8.7417**	**8.9531**	**77.5249**	**860**	**1.9458**	**13.3375**	**13.4787**	**81.6996**
87	**2.0230**	**8.6766**	**8.9093**	**76.8758**	**870**	**2.0335**	**13.2755**	**13.4304**	**81.2914**
88	**2.1143**	**8.6065**	**8.8624**	**76.1980**	**880**	**2.1262**	**13.2071**	**13.3771**	**80.8545**
89	**2.2071**	**8.5323**	**8.8131**	**75.4967**	**890**	**2.2248**	**13.1313**	**13.3184**	**80.3839**
90	**2.3112**	**8.4474**	**8.7579**	**74.6988**	**900**	**2.3304**	**13.0472**	**13.2537**	**79.8729**
91	**2.4310**	**8.3487**	**8.6955**	**73.7652**	**910**	**2.4461**	**12.9522**	**13.1812**	**79.3053**
92	**2.5594**	**8.2432**	**8.6314**	**72.7510**	**920**	**2.5727**	**12.8445**	**13.0996**	**78.6738**
93	**2.7053**	**8.1191**	**8.5579**	**71.5716**	**930**	**2.7139**	**12.7212**	**13.0075**	**77.9575**
94	**2.8337**	**7.9895**	**8.4771**	**70.4714**	**940**	**2.8747**	**12.5766**	**12.9009**	**77.1248**
95	**3.0121**	**7.8115**	**8.3721**	**68.9136**	**950**	**3.0624**	**12.4044**	**12.7768**	**76.1322**
96	**3.2254**	**7.5987**	**8.2549**	**67.0000**	**960**	**3.2890**	**12.1902**	**12.6261**	**74.9010**
97	**3.5154**	**7.2978**	**8.1003**	**64.2794**	**970**	**3.5799**	**11.9110**	**12.4373**	**73.2716**
98	**3.8973**	**6.9069**	**7.9306**	**60.5657**	**980**	**3.9827**	**11.5149**	**12.1843**	**70.9207**
99	**4.4507**	**6.3621**	**7.7643**	**55.0249**	**990**	**4.6672**	**10.8299**	**11.7927**	**66.6861**
100	**5.9910**	**4.7076**	**7.6193**	**38.1595**	**1000**	**8.2948**	**6.9694**	**10.8341**	**40.0374**

This next set of graphs depicts the gravitational attraction from a range of points within the material ring itself.



It is clear from these two graphs that there is a pronounced negative gravity at the innermost radius of the thin ring. It is equally clear that there is a comparable positive gravity at the outermost radius of the thin ring. These two extremes occur as abrupt spikes.

In both cases the center of gravitational attraction in the thin ring is represented by a ring whose radius is located between 20% and 23% of the difference between the innermost radius and the outermost radius from the innermost radius of the thin ring.

Here is the third program for calculating the gravitational parameters for the thin ring. This program works for all points outside the thin ring provided that the point in question lies on the same plane as the thin ring.

```
  REM LIBERTY BASIC v4.03
  REM ThinRing03.bas

  REM This program is only for calculating for a Thin Ring
  REM outside the body.

  REM Define Variables (VAR):
  REM VAR   a = inner radius fom center.
  REM VAR   b = center of scan from center.
  REM VAR   c = outer radius from center = 100 units.
  REM VAR   d = secondary radius of scan.
  REM VAR   p = pi = 3.14159.
  REM VAR xlo = x-component of intercept of VAR a and VAR b.
  REM VAR ylo = y-component of intercept of VAR a and VAR b.
  REM VAR mlo = slope of VAR d.
  REM VAR qlo = angle in radians between intercept of
  REM           Var a and VAR b with respect to center of VAR b.
  REM VAR xhi = x-component of intercept of VAR c and VAR b.
  REM VAR yhi = y-component of intercept of VAR c and VAR b.
  REM VAR mhi = slope of VAR d.
  REM VAR qhi = angle in radians between intercept of
  REM           Var c and VAR b with respect to center of VAR b.
  REM VAR qin = increment of scanning angle q neccessary for one
  REM           unit along circumference in radians.
  REM VAR qsc = Angle of innnermost scan in radians.
  REM VAR xgf = x-component of gravitational force.
  REM VAR ygf = y-component of gravitational force.
  REM VAR xsf = x-component of Sum of gravitational force.
  REM VAR xsf = y-component of Sum of gravitational force.
  REM VAR xst = x-component of Sub-Total of gravitational force.
  REM VAR yst = y-component of Sub-Total of gravitational force.
  REM VAR xtf = x-component of Total gravitational force.
  REM VAR ytf = y-component of Total gravitational force.
  REM VAR ngf = Normal gravitational force for hemisphere.
  REM VAR qtg = Angle of gravational vector.
  REM VAR bli = Limit of sampling greater than 100.


  REM Load constants:
  LET   p = 3.14159

  REM Enter voluntary data:
INPUT "Enter outer radius (c)          : "; c
INPUT "Enter inner radius (a) a<c      : "; a
INPUT "Enter sampling iimit (bli) bli>c: "; bli

  REM Establish outermost loop.
  LET xtg = 0
  LET ytg = 0
```

```
   LET b = c + 1
   WHILE b <= bli

   REM Initiate WHILE loop for VAR b radius:
   LET d = 1.0001
   LET xtf = 0
   LET ytf = 0
 WHILE d <= (b + c)

   REM Calculate parameters for scan next WHILE loop:

   LET qin = 1/d

    IF d < (c + b) AND d > (a + b)  THEN
   LET xlo = (d - b)
   LET ylo = 0
   LET mlo = 0
   LET qlo = 0
END IF

    IF d < (a + b) AND d > (b - a) THEN
   LET xlo = (d^2 - a^2 - b^2)/(2 * b)
   LET ylo = (a^2 - xlo^2)^(1/2)
   LET mlo = ylo/(xlo + b)
   LET qlo = acs((xlo + b)/d)
END IF

   IF d < (b - a) AND d > (b - c)  THEN
   LET xlo = (d - b)
   LET ylo = 0
   LET mlo = 0
   LET qlo = 0
END IF

    IF d = (b - c)  THEN
   LET xhi = (-1 * c)
   LET yhi = 0
   LET mhi = 0
   LET qhi = 0
END IF

   IF d = (b + c)  THEN
   LET xhi = (c)
   LET yhi = 0
   LET mhi = 0
   LET qhi = 0
END IF

    IF d > (b - c) AND d < (b + c) THEN
   LET xhi = (d^2 - c^2 - b^2)/(2 * b)
   LET yhi = (c^2 - xhi^2)^(1/2)
   LET mhi = yhi/(xhi + b)
   LET qhi = acs((xhi + b)/d)
END IF
```

```
  REM Establish inner WHILE loop:
  LET qsc = qlo
  LET xsf = 0
  LET ysf = 0
WHILE qsc <= qhi

  REM Do innermost calculations:
  LET xgf =  (cos(qsc))/(d^2)
  LET ygf =  (sin(qsc))/(d^2)

  REM Close out inner WHILE loop:
  LET xsf = xsf + xgf
  LET ysf = ysf + ygf
  LET qsc = qsc + qin
  LET xst = xsf
  LET yst = ysf
WEND

  REM Add subtotal gravitational forces
  LET xtf = xtf + xst
  LET ytf = ytf + yst

  REM Close out WHILE loop for VAR b radius:
  LET d = d + 1
 WEND


 LET qtg = acs(xtf/((xtf^2 + ytf^2)^0.5)) * (180/p)
 LET ngf = (xtf^2 + ytf^2)^0.5

PRINT using("####",b);
PRINT using("#####.####",xtf);
PRINT using("#####.####",ytf);
PRINT using("#####.####",ngf);
PRINT using("#####.####",qtg)

  REM Close out first WHILE loop.
  LET b = b + 1
 WEND

  REM End program:
  END
```

Here are two sample runs for ThinRing03.bas. The “quick Run” return on the left is “as-is.” The “detailed run” on the right has been reduced to multiples of ten. The two cases are similar. The “quick runs” were originally intended for use in debugging the program.

Quick Run					Detailed Run				
Enter outer radius (c) : 100					Enter outer radius (c) : 1000				
Enter inner radius (a) a<c : 50					Enter inner radius (a) a<c : 500				
Enter sampling iimit (bli) bli>c: 200					Enter sampling iimit (bli) bli>c: 2000				
d	xtf	ytf	ngf	qtg	d	xtf	ytf	ngf	qtg
101	5.3870	3.2437	6.2882	31.0535	1010	5.8193	3.2206	6.6511	28.9619
102	4.9131	2.5622	5.5410	27.5422	1020	5.1599	2.5606	5.7603	26.3933
103	4.5782	2.1706	5.0667	25.3660	1030	4.7658	2.1836	5.2422	24.6163
104	4.3606	1.9272	4.7675	23.8433	1040	4.4908	1.9224	4.8850	23.1744
105	4.1656	1.7245	4.5084	22.4894	1050	4.2803	1.7261	4.6152	21.9628
106	3.9967	1.5578	4.2895	21.2948	1060	4.1058	1.5688	4.3953	20.9112
107	3.8579	1.4296	4.1143	20.3322	1070	3.9614	1.4397	4.2149	19.9726
108	3.7569	1.3328	3.9863	19.5322	1080	3.8381	1.3307	4.0622	19.1216
109	3.6512	1.2382	3.8554	18.7325	1090	3.7297	1.2371	3.9295	18.3498
110	3.5541	1.1536	3.7367	17.9825	1100	3.6335	1.1554	3.8128	17.6392
111	3.4686	1.0806	3.6330	17.3039	1110	3.5467	1.0832	3.7084	16.9832
112	3.4071	1.0214	3.5569	16.6880	1120	3.4692	1.0191	3.6158	16.3703
113	3.3409	0.9609	3.4763	16.0457	1130	3.3985	0.9615	3.5319	15.7978
114	3.2861	0.9111	3.4100	15.4973	1140	3.3337	0.9095	3.4555	15.2598
115	3.2217	0.8621	3.3350	14.9813	1150	3.2732	0.8622	3.3849	14.7572
116	3.1719	0.8207	3.2764	14.5074	1160	3.2182	0.8190	3.3208	14.2789
117	3.1303	0.7844	3.2271	14.0673	1170	3.1668	0.7795	3.2613	13.8280
118	3.0849	0.7471	3.1741	13.6133	1180	3.1189	0.7430	3.2062	13.3999
119	3.0406	0.7111	3.1227	13.1625	1190	3.0734	0.7094	3.1542	12.9966
120	3.0006	0.6798	3.0767	12.7655	1200	3.0315	0.6781	3.1064	12.6086
121	2.9655	0.6520	3.0363	12.3998	1210	2.9918	0.6490	3.0614	12.2397
122	2.9322	0.6260	2.9983	12.0508	1220	2.9545	0.6220	3.0193	11.8884
123	2.9007	0.6014	2.9624	11.7129	1230	2.9183	0.5966	2.9787	11.5538
124	2.8676	0.5764	2.9249	11.3648	1240	2.8852	0.5730	2.9416	11.2324
125	2.8380	0.5533	2.8914	11.0331	1250	2.8536	0.5508	2.9063	10.9245
126	2.8105	0.5322	2.8604	10.7228	1260	2.8233	0.5298	2.8725	10.6291
127	2.7836	0.5124	2.8304	10.4303	1270	2.7948	0.5102	2.8410	10.3458
128	2.7540	0.4957	2.7982	10.2036	1280	2.7666	0.4916	2.8100	10.0764
129	2.7292	0.4776	2.7707	9.9266	1290	2.7406	0.4741	2.7813	9.8149
130	2.7064	0.4610	2.7454	9.6666	1300	2.7156	0.4575	2.7539	9.5638
131	2.6853	0.4455	2.7220	9.4201	1310	2.6917	0.4418	2.7277	9.3221
132	2.6638	0.4298	2.6983	9.1658	1320	2.6681	0.4269	2.7021	9.0910
133	2.6440	0.4161	2.6765	8.9434	1330	2.6462	0.4128	2.6783	8.8668
134	2.6251	0.4032	2.6559	8.7312	1340	2.6252	0.3994	2.6554	8.6505
135	2.6048	0.3902	2.6338	8.5187	1350	2.6050	0.3866	2.6335	8.4423
136	2.5881	0.3786	2.6156	8.3234	1360	2.5847	0.3744	2.6116	8.2421
137	2.5702	0.3666	2.5962	8.1170	1370	2.5661	0.3628	2.5917	8.0476
138	2.5528	0.3551	2.5774	7.9186	1380	2.5480	0.3517	2.5721	7.8597
139	2.5368	0.3446	2.5601	7.7358	1390	2.5306	0.3411	2.5535	7.6770
140	2.5215	0.3345	2.5436	7.5567	1400	2.5140	0.3311	2.5357	7.5020
141	2.5076	0.3252	2.5286	7.3890	1410	2.4971	0.3214	2.5177	7.3334
142	2.4865	0.3158	2.5065	7.2382	1420	2.4814	0.3121	2.5010	7.1689
143	2.4728	0.3068	2.4917	7.0720	1430	2.4663	0.3032	2.4849	7.0095
144	2.4595	0.2982	2.4775	6.9128	1440	2.4517	0.2947	2.4693	6.8551
145	2.4473	0.2902	2.4644	6.7634	1450	2.4369	0.2866	2.4537	6.7070
146	2.4349	0.2822	2.4512	6.6098	1460	2.4232	0.2788	2.4392	6.5623
147	2.4218	0.2743	2.4373	6.4623	1470	2.4099	0.2712	2.4251	6.4216
148	2.4110	0.2678	2.4258	6.3381	1480	2.3970	0.2640	2.4115	6.2848
149	2.3982	0.2607	2.4123	6.2044	1490	2.3839	0.2570	2.3977	6.1543
150	2.3876	0.2542	2.4011	6.0783	1500	2.3719	0.2504	2.3851	6.0258

Quick Run (cont.)

Enter outer radius (c)   : 100
Enter inner radius (a) a<c   : 50
Enter sampling iimit (bli) bli>c: 200

d	xtf	ytf	ngf	qtg
151	2.3761	0.2476	2.3889	5.9494
152	2.3664	0.2417	2.3787	5.8310
153	2.3559	0.2354	2.3676	5.7062
154	2.3463	0.2296	2.3575	5.5892
155	2.3366	0.2239	2.3473	5.4747
156	2.3207	0.2184	2.3309	5.3757
157	2.3123	0.2136	2.3221	5.2765
158	2.3035	0.2084	2.3129	5.1696
159	2.2948	0.2035	2.3038	5.0686
160	2.2866	0.1990	2.2953	4.9747
161	2.2786	0.1944	2.2869	4.8758
162	2.2691	0.1897	2.2770	4.7790
163	2.2618	0.1855	2.2693	4.6888
164	2.2545	0.1814	2.2618	4.6015
165	2.2474	0.1779	2.2545	4.5261
166	2.2402	0.1741	2.2470	4.4436
167	2.2335	0.1704	2.2400	4.3618
168	2.2270	0.1669	2.2333	4.2853
169	2.2140	0.1629	2.2200	4.2073
170	2.2077	0.1595	2.2134	4.1317
171	2.2014	0.1560	2.2070	4.0545
172	2.1956	0.1529	2.2009	3.9844
173	2.1895	0.1498	2.1946	3.9145
174	2.1831	0.1467	2.1880	3.8443
175	2.1778	0.1440	2.1826	3.7834
176	2.1709	0.1411	2.1755	3.7183
177	2.1656	0.1384	2.1700	3.6569
178	2.1604	0.1358	2.1647	3.5959
179	2.1548	0.1331	2.1589	3.5359
180	2.1494	0.1306	2.1533	3.4763
181	2.1446	0.1281	2.1484	3.4187
182	2.1398	0.1257	2.1434	3.3621
183	2.1292	0.1229	2.1328	3.3048
184	2.1245	0.1206	2.1279	3.2493
185	2.1201	0.1184	2.1234	3.1966
186	2.1159	0.1164	2.1191	3.1478
187	2.1116	0.1144	2.1147	3.1011
188	2.1070	0.1124	2.1100	3.0523
189	2.1028	0.1104	2.1056	3.0043
190	2.0977	0.1084	2.1005	2.9575
191	2.0936	0.1065	2.0963	2.9114
192	2.0893	0.1046	2.0919	2.8665
193	2.0853	0.1028	2.0879	2.8232
194	2.0815	0.1011	2.0840	2.7797
195	2.0777	0.0993	2.0801	2.7360
196	2.0740	0.0976	2.0763	2.6937
197	2.0654	0.0956	2.0676	2.6506
198	2.0620	0.0941	2.0642	2.6128
199	2.0588	0.0926	2.0609	2.5757
200	2.0553	0.0912	2.0573	2.5404

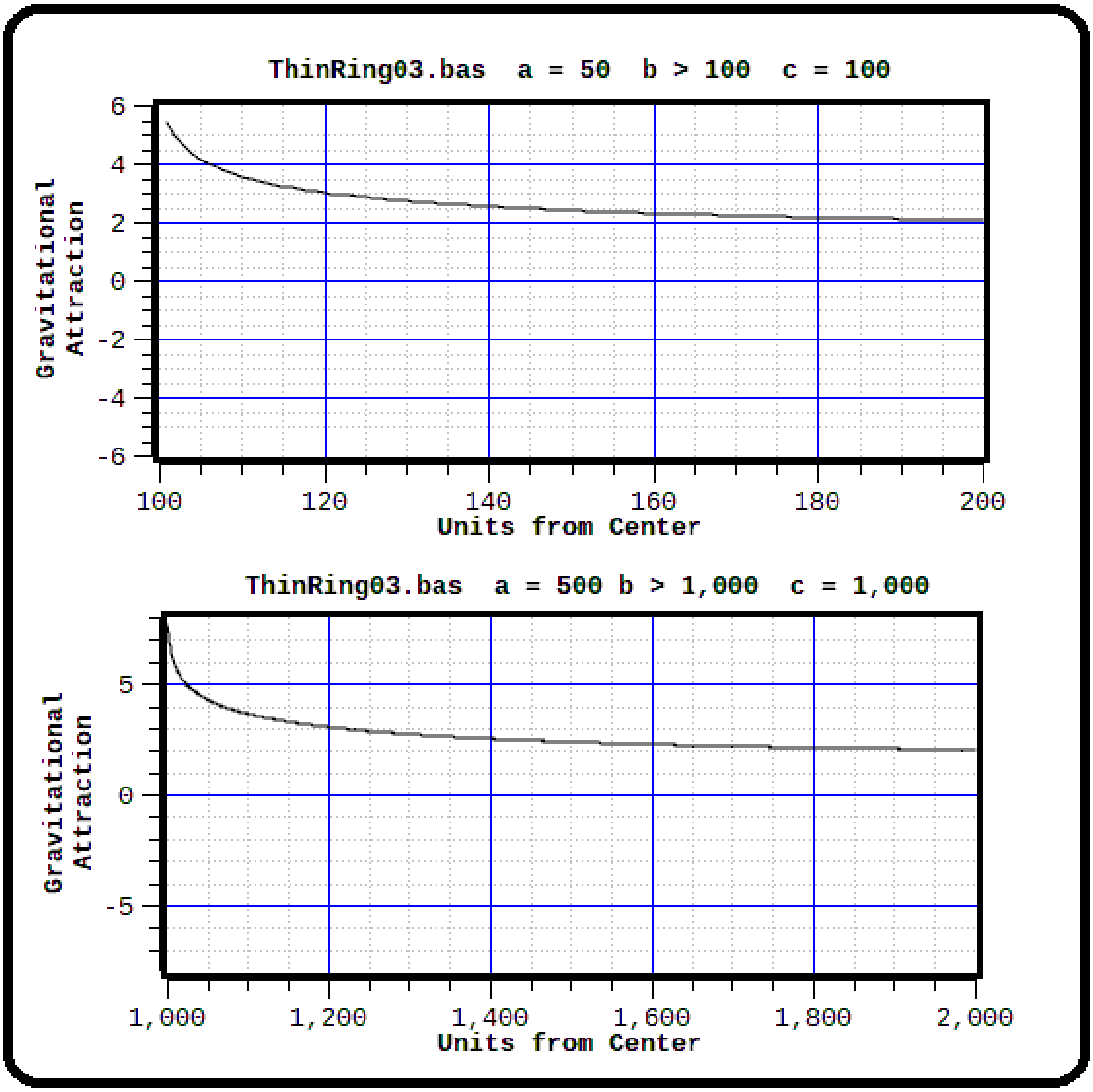
Detailed Run (cont.)

Enter outer radius (c)   : 1000
Enter inner radius (a) a<c   : 500
Enter sampling iimit (bli) bli>c: 2000

d	xtf	ytf	ngf	qtg
1510	2.3600	0.2439	2.3726	5.9009
1520	2.3487	0.2377	2.3607	5.7795
1530	2.3377	0.2318	2.3491	5.6620
1540	2.3263	0.2260	2.3372	5.5487
1550	2.3158	0.2204	2.3263	5.4375
1560	2.3056	0.2151	2.3156	5.3293
1570	2.2957	0.2099	2.3053	5.2242
1580	2.2854	0.2049	2.2946	5.1229
1590	2.2761	0.2001	2.2848	5.0235
1600	2.2669	0.1954	2.2753	4.9268
1610	2.2580	0.1909	2.2660	4.8324
1620	2.2487	0.1865	2.2564	4.7415
1630	2.2403	0.1823	2.2477	4.6518
1640	2.2319	0.1782	2.2390	4.5648
1650	2.2239	0.1742	2.2307	4.4799
1660	2.2162	0.1704	2.2227	4.3972
1670	2.2079	0.1667	2.2142	4.3174
1680	2.2005	0.1631	2.2065	4.2387
1690	2.1931	0.1596	2.1989	4.1621
1700	2.1859	0.1562	2.1915	4.0873
1710	2.1784	0.1529	2.1838	4.0150
1720	2.1716	0.1497	2.1768	3.9441
1730	2.1649	0.1466	2.1699	3.8746
1740	2.1584	0.1436	2.1632	3.8069
1750	2.1515	0.1407	2.1561	3.7413
1760	2.1453	0.1379	2.1498	3.6766
1770	2.1393	0.1351	2.1436	3.6134
1780	2.1332	0.1324	2.1373	3.5520
1790	2.1274	0.1298	2.1314	3.4916
1800	2.1212	0.1273	2.1250	3.4334
1810	2.1156	0.1248	2.1193	3.3758
1820	2.1101	0.1224	2.1136	3.3196
1830	2.1047	0.1201	2.1081	3.2648
1840	2.0990	0.1178	2.1023	3.2116
1850	2.0939	0.1156	2.0971	3.1592
1860	2.0887	0.1134	2.0918	3.1078
1870	2.0838	0.1113	2.0867	3.0575
1880	2.0784	0.1093	2.0813	3.0090
1890	2.0737	0.1073	2.0765	2.9610
1900	2.0691	0.1053	2.0718	2.9139
1910	2.0644	0.1034	2.0670	2.8681
1920	2.0600	0.1016	2.0625	2.8228
1930	2.0551	0.0998	2.0575	2.7793
1940	2.0508	0.0980	2.0531	2.7362
1950	2.0465	0.0963	2.0488	2.6941
1960	2.0423	0.0946	2.0445	2.6525
1970	2.0378	0.0930	2.0399	2.6125
1980	2.0338	0.0914	2.0359	2.5728
1990	2.0298	0.0898	2.0318	2.5340
2000	2.0259	0.0883	2.0278	2.4959

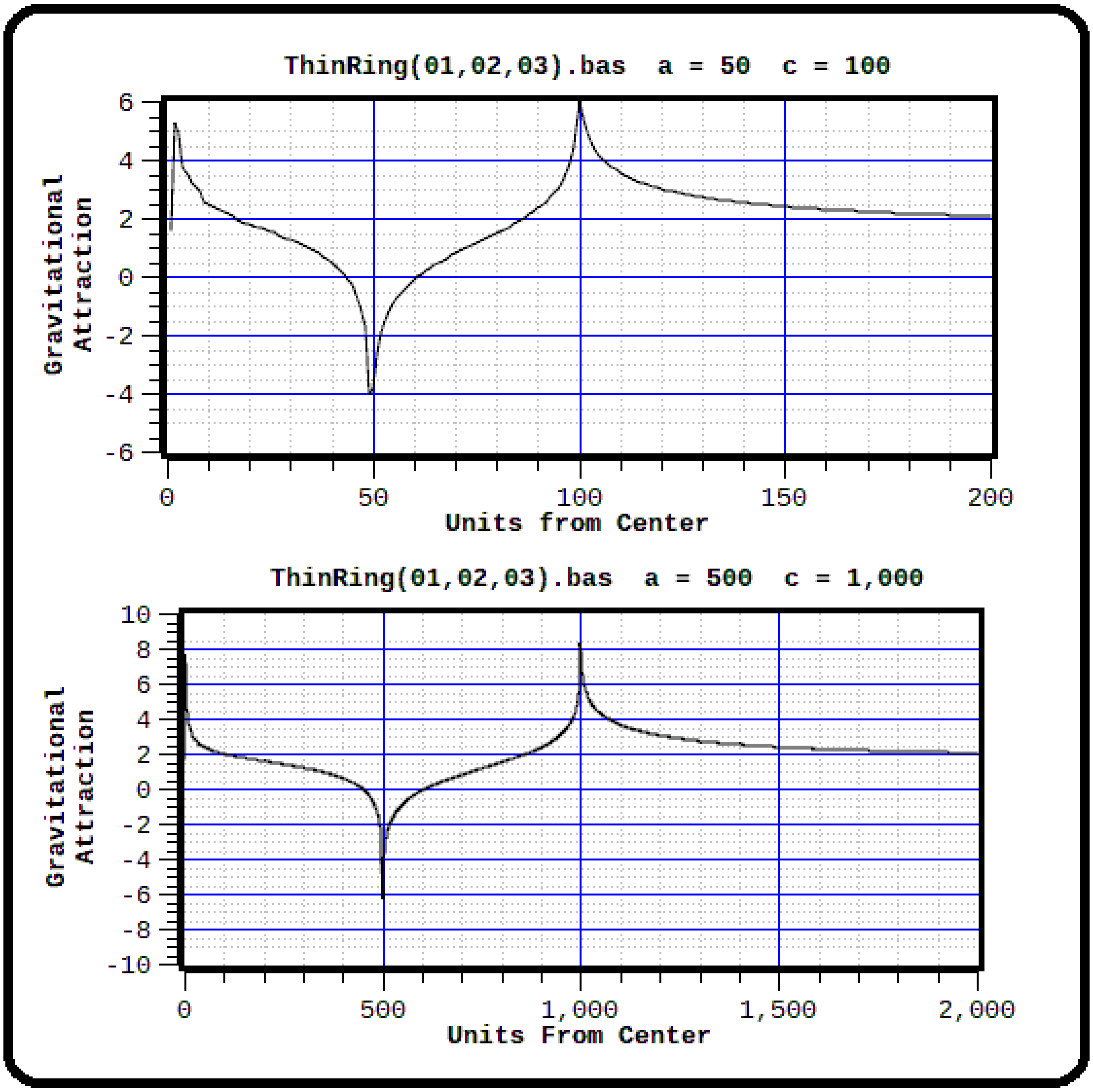
The entered parameters were the same as the previous two sets of runs from “ThinRing01.bas” and “ThinRing02.bas.”

Here are the graphs of the two preceding runs of ThinRing03.bas.



The next set of graphs is a composite of the preceding three graphs.

Finally we have a composite graph of ThinRing01.bas, ThinRing02.bas, and ThinRing03.bas.



These composite graphs appear to indicate that the gravitational attraction in the plane of the thin ring has the following oddities;

1. There are three spikes and three loci of zero gravity
2. There is a negative gravitational spike at the innermost radius.
3. There are two positive gravitational spikes; One at the outermost radius and the other near the center.
4. There are three areas of zero gravity; One at the center, one is a ring just a little inside the innermost radius, and the last is a ring a little inside the material ring itself from the innermost radius.

Gravitational Attraction of a Hollow World

The preceding section on the thin ring was necessarily introduced with regards to the hollow world. This is an ideal model of either uniform density or zero density. The thin ring section introduced the elementary algebra and trigonometry a well as the three programs for calculating the gravitational effects along the plane of the thin ring.

In this section regarding the gravitational attraction of the hollow world, the same three programs will be used, but with two lines altered.

The applicable model of the hollow world is that of a hemisphere laid on a flat plane. The observer is an inhabitant of the flat plane. The observer sees a half-circle arcing out of the flat plane. For the gravitational attraction the radius of the half-circle is multiplied by [π]. The same might be said for the gravitational compression except that the half-circle needs to be multiplied by the mean of the sines [2/π], or [(y x π) x (2/π) = 2 x y]. Here are the change from the thin ring to the hollow world. The PRINT characters will need to be rearranged as well as the remarks about the titles and the intents.

```
[Thin Ring]
REM Do innermost calculations:
LET xgf =  (cos(qsc))/(d^2)
LET ygf =  (sin(qsc))/(d^2)

[Hollow World]
REM Do innermost calculations:
LET xgf =  (cos(qsc))/(d^2)   *   (p * d * sin(qsc))
LET ygf =  (sin(qsc))/(d^2)   *   (2 * d * sin(qsc))
```

The following are the three modified programs as the results of the sample runs. The sample runs runs use the same parameters as the parameters that were employed for the thin ring. This will permit a fair comparison.

```
  REM LIBERTY BASIC v4.03
  REM HollowWorld01.bas

  REM This program is only capable of gravitationally evaluating
  REM for a point within the interior space of a hollow world.

  REM Define Variables (VAR):
  REM VAR   a = inner radius fom center.
  REM VAR   b = center of scan from center.
  REM VAR   c = outer radius from center = 100 units.
  REM VAR   d = secondary radius of scan.
  REM VAR   p = pi = 3.14159.
  REM VAR xlo = x-component of intercept of VAR a and VAR b.
  REM VAR ylo = y-component of intercept of VAR a and VAR b.
  REM VAR mlo = slope of VAR d.
  REM VAR qlo = angle in radians between intercept of
  REM           Var a and VAR b with respect to center of VAR b.
  REM VAR xhi = x-component of intercept of VAR c and VAR b.
  REM VAR yhi = y-component of intercept of VAR c and VAR b.
  REM VAR mhi = slope of VAR d.
  REM VAR qhi = angle in radians between intercept of
  REM           Var c and VAR b with respect to center of VAR b.
  REM VAR qin = increment of scanning angle q neccessary for one
  REM           unit along circumference in radians.
  REM VAR qsc = Angle of innermost scan in radians.
  REM VAR xgf = x-component of gravitational force.
  REM VAR ygf = y-component of gravitational force.
  REM VAR xsf = x-component of Sum of gravitational force.
  REM VAR xsf = y-component of Sum of gravitational force.
  REM VAR xst = x-component of Sub-Total of gravitational force.
  REM VAR yst = y-component of Sub-Total of gravitational force.
  REM VAR xtf = x-component of Total gravitational force.
  REM VAR ytf = y-component of Total gravitational force.
  REM VAR ngf = Normal gravitational force for hemisphere.
  REM VAR qtg = Angle of gravational vector.


  REM Load constants:
  LET   p = 3.14159

  REM Enter voluntary data:
INPUT "Enter outer radius (c)    : "; c
INPUT "Enter inner radius (a) a<c: "; a

  REM Establish outermost loop.
  LET xtg = 0
  LET ytg = 0
  LET b = 1
  WHILE b < a

  REM Initiate WHILE loop for VAR b radius:
  LET d = 1.0001
  LET xtf = 0
  LET ytf = 0
WHILE d <= (b + c)
```

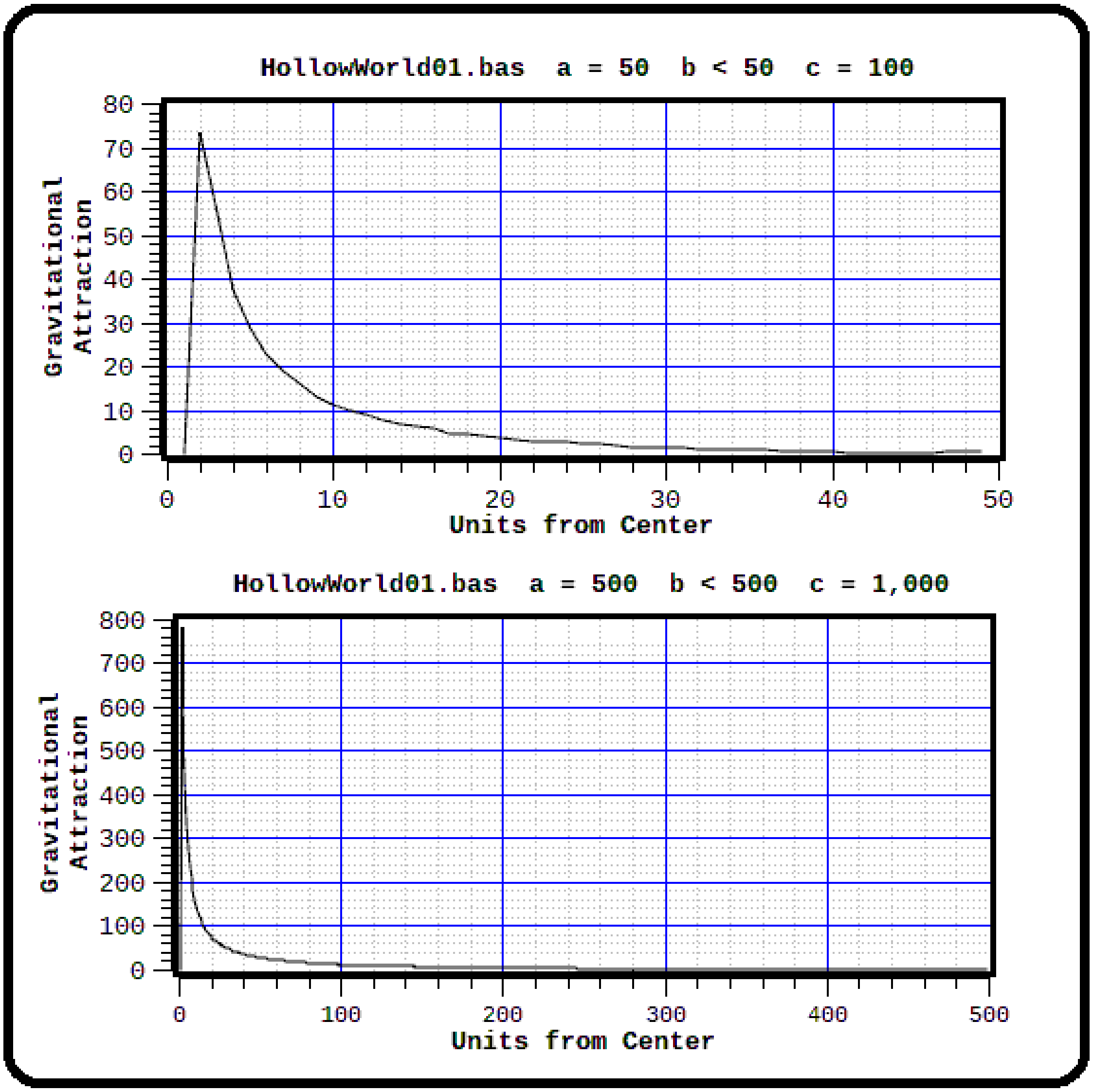
```
   REM Calculate parameters for scan next WHILE loop:

   LET qin = 1/d

    IF d >= (a + b) AND d <= (c + b)  THEN
   LET xlo = (a - d)
   LET ylo = 0
   LET mlo = 0
   LET qlo = 0
END IF

    IF d < (a + b) AND d > (a - b) THEN
   LET xlo = (d^2 - a^2 - b^2)/(2 * b)
   LET ylo = (a^2 - xlo^2)^(1/2)
   LET mlo = ylo/(xlo + b)
   LET qlo = acs((xlo + b)/d)
END IF

    IF d > (a - b) AND d < (c - b) THEN
   LET xhi = (c - d)
   LET yhi = 0
   LET mhi = 0
   LET qhi = p
END IF

    IF d > (c - b) THEN
   LET xhi = (d^2 - c^2 - b^2)/(2 * b)
   LET yhi = (c^2 - xhi^2)^(1/2)
   LET mhi = yhi/(xhi + b)
   LET qhi = acs((xhi + b)/d)
END IF

   REM Establish inner WHILE loop:
   LET qsc = qlo
   LET xsf = 0
   LET ysf = 0
 WHILE qsc <= qhi

   REM Do innermost calculations:
   LET xgf =  (cos(qsc))/(d^2)   *   (p * d * sin(qsc))
   LET ygf =  (sin(qsc))/(d^2)   *   (2 * d * sin(qsc))

   REM Close out inner WHILE loop:
   LET xsf = xsf + xgf
   LET ysf = ysf + ygf
   LET qsc = qsc + qin
   LET xst = xsf
   LET yst = ysf
 WEND

   REM Add subtotal gravitational forces
   LET xtf = xtf + xst
   LET ytf = ytf + yst
```

```
  REM Close out WHILE loop for VAR b radius:
  LET d = d + 1
 WEND


 LET qtg = acs(xtf/((xtf^2 + ytf^2)^0.5)) * (180/p)
 LET ngf = (xtf^2 + ytf^2)^0.5

PRINT using("####",b);
PRINT using("#########",xtf);
PRINT using("#########",ytf);
PRINT using("#########",ngf);
PRINT using("#####.####",qtg)

  REM Close out first WHILE loop.
  LET b = b + 1
 WEND

  REM End program:
  END
```

Here are two runs from the preceding program. They are similar configurations. The only difference is that the one on the right is scaled up by a factor of ten with respect to the one on the left. The one on the right has been cropped into multiples of ten for comparison.

Quick Run					Detailed Run				
Enter outer radius (c) : 100					Enter outer radius (c) : 1000				
Enter inner radius (a) a<c: 50					Enter inner radius (a) a<c: 500				
d	**xtf**	**ytf**	**ngf**	**qtg**	**d**	**xtf**	**ytf**	**ngf**	**qtg**
1	0.00	157.11	157.1082	90.0010	10	159	1604	1612	84.3344
2	73.50	230.61	242.0405	72.3218	20	75	1582	1584	87.2796
3	54.51	186.60	194.4020	73.7159	30	48	1577	1578	88.2463
4	37.34	171.88	175.8866	77.7446	40	35	1576	1577	88.7306
5	28.63	166.78	169.2194	80.2602	50	27	1576	1576	89.0252
6	22.77	164.16	165.7283	82.1032	60	22	1577	1577	89.2135
7	18.58	162.59	163.6438	83.4811	70	18	1578	1578	89.3518
8	16.01	161.85	162.6396	84.3494	80	15	1580	1580	89.4518
9	12.72	161.00	161.5008	85.4835	90	13	1581	1582	89.5275
10	11.23	160.79	161.1773	86.0058	100	11	1584	1584	89.5924
11	9.92	160.74	161.0424	86.4686	110	10	1586	1586	89.6428
12	8.74	160.73	160.9690	86.8884	120	9	1589	1589	89.6857
13	7.67	160.78	160.9642	87.2693	130	8	1592	1592	89.7209
14	6.81	160.97	161.1122	87.5789	140	7	1595	1595	89.7501
15	6.12	161.20	161.3140	87.8256	150	6	1599	1599	89.7769
16	5.68	161.54	161.6412	87.9858	160	6	1603	1603	89.7992
17	4.52	161.78	161.8409	88.4010	170	5	1607	1607	89.8186
18	4.27	162.18	162.2385	88.4928	180	5	1612	1612	89.8370
19	3.86	162.59	162.6407	88.6386	190	4	1616	1616	89.8528
20	3.51	163.13	163.1717	88.7678	200	4	1622	1622	89.8653
21	3.23	163.60	163.6311	88.8673	210	3	1627	1627	89.8786
22	2.83	164.24	164.2636	89.0115	220	3	1633	1633	89.8895
23	2.69	164.84	164.8622	89.0645	230	3	1639	1639	89.8993
24	2.46	165.48	165.5027	89.1484	240	3	1646	1646	89.9095
25	2.24	166.21	166.2291	89.2264	250	2	1653	1653	89.9172
26	2.09	167.04	167.0523	89.2816	260	2	1660	1660	89.9245
27	1.62	167.70	167.7049	89.4468	270	2	1668	1668	89.9322
28	1.52	168.58	168.5835	89.4844	280	2	1677	1677	89.9378
29	1.39	169.52	169.5230	89.5296	290	2	1685	1685	89.9449
30	1.22	170.53	170.5344	89.5914	300	2	1695	1695	89.9493
31	1.14	171.52	171.5189	89.6186	310	1	1705	1705	89.9545
32	1.08	172.59	172.5963	89.6414	320	1	1715	1715	89.9587
33	0.88	173.70	173.7021	89.7091	330	1	1726	1726	89.9629
34	0.81	174.91	174.9081	89.7350	340	1	1738	1738	89.9669
35	0.67	176.28	176.2808	89.7835	350	1	1751	1751	89.9714
36	0.73	177.58	177.5787	89.7634	360	1	1764	1764	89.9740
37	0.66	179.11	179.1113	89.7905	370	1	1778	1778	89.9776
38	0.41	180.65	180.6456	89.8700	380	1	1794	1794	89.9800
39	0.28	182.41	182.4065	89.9133	390	1	1810	1810	89.9834
40	0.27	184.14	184.1445	89.9148	400	0	1827	1827	89.9854
41	0.22	186.21	186.2127	89.9318	410	0	1846	1846	89.9873
42	0.21	188.28	188.2768	89.9368	420	0	1867	1867	89.9900
43	0.16	190.52	190.5201	89.9513	430	0	1889	1889	89.9917
44	0.06	193.11	193.1090	89.9827	440	0	1913	1913	89.9932
45	0.06	195.89	195.8943	89.9837	450	0	1940	1940	89.9956
46	0.20	199.05	199.0530	89.9420	460	0	1970	1970	89.9974
47	0.27	202.73	202.7270	89.9233	470	0	2003	2003	89.9978
48	0.31	207.04	207.0405	89.9140	480	0	2043	2043	89.9990
49	0.55	212.51	212.5130	89.8522	490	0	2092	2092	89.9984

Here are two graphs of the preceding two runs. Both have been taken from the raw uncropped returns.



There is an issue here with the spike on the left of both graphs. Because this spike is not scaled it must be assumed to be an issue with the program itself when the sampling distance from center [b] approaches [1]. Thus, a quick analysis of these two graphs will indicate that within the interior space of an ideal hollow world; That the gravitational attraction is at all points equal to zero [0].

Here is the program adjusted for the gravitational attraction within the shell of an ideal hollow world.

```
  REM LIBERTY BASIC v4.03
  REM HollowWorld02.bas

  REM This program is restricted to the shell area
  REM of the hollow world.

  REM Define Variables (VAR):
  REM VAR   a = inner radius from center.
  REM VAR   b = center of scan from center.
  REM VAR   c = outer radius from center = 100 units.
  REM VAR   d = secondary radius of scan.
  REM VAR   p = pi = 3.14159.
  REM VAR xlo = x-component of intercept of VAR a and VAR b.
  REM VAR ylo = y-component of intercept of VAR a and VAR b.
  REM VAR mlo = slope of VAR d.
  REM VAR qlo = angle in radians between intercept of
  REM           Var a and VAR b with respect to center of VAR b.
  REM VAR xhi = x-component of intercept of VAR c and VAR b.
  REM VAR yhi = y-component of intercept of VAR c and VAR b.
  REM VAR mhi = slope of VAR d.
  REM VAR qhi = angle in radians between intercept of
  REM           Var c and VAR b with respect to center of VAR b.
  REM VAR qin = increment of scanning angle q neccessary for one
  REM           unit along circumference in radians.
  REM VAR qsc = Angle of innermost scan in radians.
  REM VAR xgf = x-component of gravitational force.
  REM VAR ygf = y-component of gravitational force.
  REM VAR xsf = x-component of Sum of gravitational force.
  REM VAR xsf = y-component of Sum of gravitational force.
  REM VAR xst = x-component of Sub-Total of gravitational force.
  REM VAR yst = y-component of Sub-Total of gravitational force.
  REM VAR xtf = x-component of Total gravitational force.
  REM VAR ytf = y-component of Total gravitational force.
  REM VAR ngf = Normal gravitational force for hemisphere.
  REM VAR qtg = Angle of gravitational vector.                        '


  REM Load constants:
  LET   p = 3.14159

  REM Enter voluntary data:
INPUT "Enter outer radius (c)    : "; c
INPUT "Enter inner radius (a) a<c: "; a

  REM Establish outermost loop.
  LET xtg = 0
  LET ytg = 0
  LET b = a
  WHILE b <= c
```

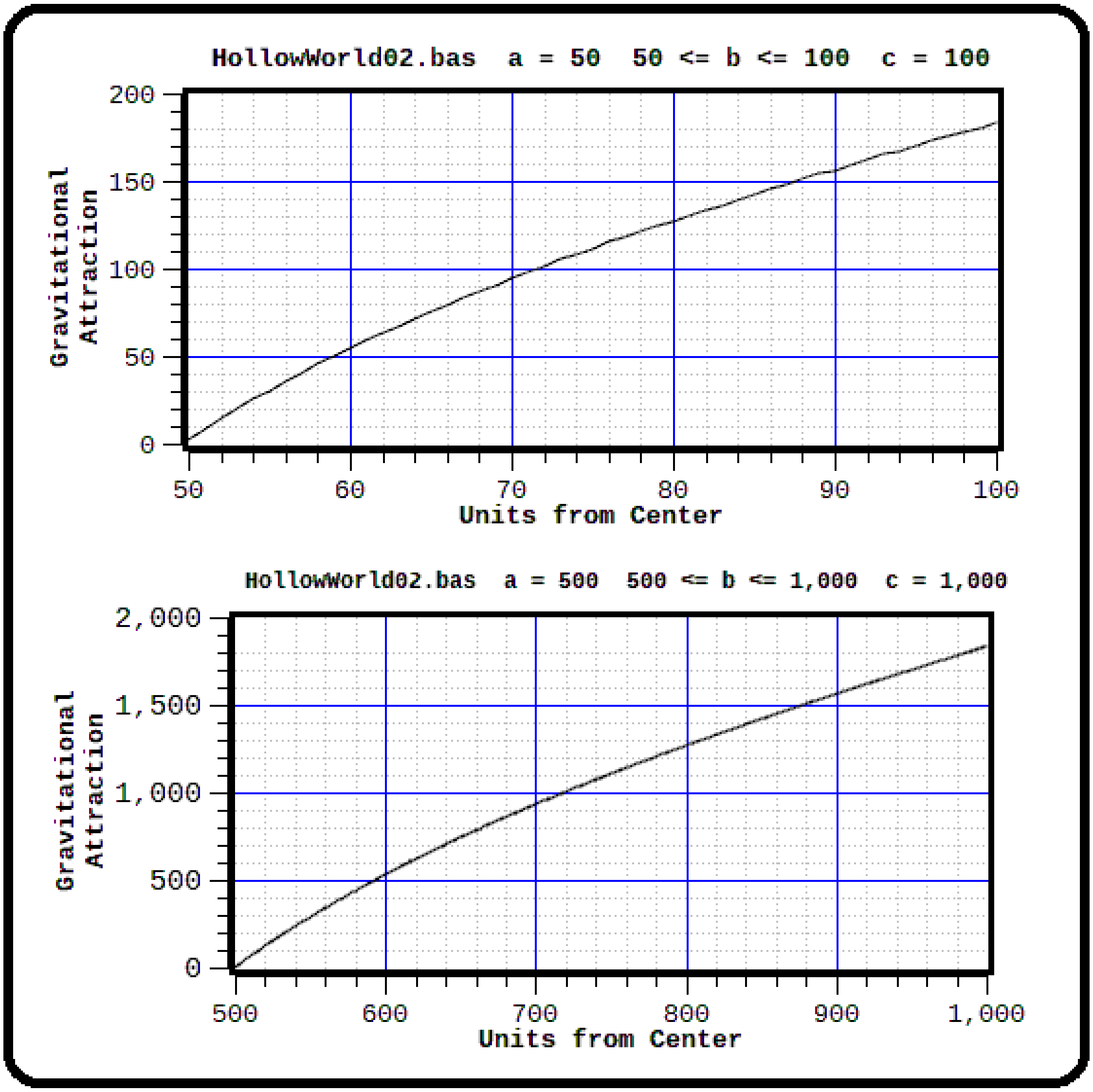
```
   REM Initiate WHILE loop for VAR b radius:
   LET d = 1.0001
   LET xtf = 0
   LET ytf = 0
 WHILE d <= (b + c)

   REM Calculate parameters for scan next WHILE loop:

   LET qin = 1/d

    IF d < (b - a) OR d > (b + a)  THEN
   LET xlo = (a - d)
   LET ylo = 0
   LET mlo = 0
   LET qlo = 0
END IF

    IF d > (b - a) AND d < (b + a) THEN
   LET xlo = (d^2 - a^2 - b^2)/(2 * b)
   LET ylo = (a^2 - xlo^2)^(1/2)
   LET mlo = ylo/(xlo + b)
   LET qlo = acs((xlo + b)/d)
END IF

    IF d <= (c - b) THEN
   LET xhi = (c - d)
   LET yhi = 0
   LET mhi = 0
   LET qhi = p
END IF

    IF d > (c - b) THEN
   LET xhi = (d^2 - c^2 - b^2)/(2 * b)
   LET yhi = (c^2 - xhi^2)^(1/2)
   LET mhi = yhi/(xhi + b)
   LET qhi = acs((xhi + b)/d)
END IF

   REM Establish inner WHILE loop:
   LET qsc = qlo
   LET xsf = 0
   LET ysf = 0
 WHILE qsc <= qhi

   REM Do innermost calculations:
   LET xgf =  (cos(qsc))/(d^2)   *   (p * d * sin(qsc))
   LET ygf =  (sin(qsc))/(d^2)   *   (2 * d * sin(qsc))

   REM Close out inner WHILE loop:
   LET xsf = xsf + xgf
   LET ysf = ysf + ygf
   LET qsc = qsc + qin
   LET xst = xsf
   LET yst = ysf
 WEND
```

```
  REM Add subtotal gravitational forces
  LET xtf = xtf + xst
  LET ytf = ytf + yst

  REM Close out WHILE loop for VAR b radius:
  LET d = d + 1
 WEND


 LET qtg = acs(xtf/((xtf^2 + ytf^2)^0.5)) * (180/p)
 LET ngf = (xtf^2 + ytf^2)^0.5

PRINT using("####",b);
PRINT using("########",xtf);
PRINT using("########",ytf);
PRINT using("########",ngf);
PRINT using("####.####",qtg)

  REM Close out first WHILE loop.
  LET b = b + 1
 WEND

  REM End program:
  END
```

Here are two sample runs from the preceding program. The two are similar. The radius of the second is 10 times higher than the first. The mass of the second one is 1,000 times greater than the first. Observe that the gravitational attraction is uniformly 10 times greater that in the second.

Quick Run					Detailed Run				
Enter outer radius (c) : 100					Enter outer radius (c) : 1000				
Enter inner radius (a) a<c: 50					Enter inner radius (a) a<c: 500				
d	xtf	ytf	ngf	qtg	d	xtf	ytf	ngf	qtg
50	2	220	220	89.4081	500	2	2169	2169	89.9383
51	8	225	225	87.8504	510	64	2237	2238	88.3713
52	14	229	229	86.4959	520	123	2279	2282	86.9158
53	20	232	233	85.1298	530	180	2310	2317	85.5492
54	25	234	235	83.8923	540	235	2334	2346	84.2517
55	30	235	237	82.6557	550	288	2352	2369	83.0159
56	35	237	239	81.4821	560	340	2366	2390	81.8300
57	40	238	241	80.3848	570	390	2376	2407	80.6885
58	45	238	242	79.2715	580	438	2383	2423	79.5856
59	50	238	243	78.1978	590	485	2387	2436	78.5162
60	54	239	245	77.1719	600	531	2389	2447	77.4759
61	59	238	246	76.1759	610	575	2389	2458	76.4624
62	63	238	246	75.1931	620	619	2387	2466	75.4711
63	67	238	247	74.2194	630	661	2384	2474	74.5009
64	71	237	248	73.2695	640	702	2378	2480	73.5482
65	75	236	248	72.3479	650	743	2372	2485	72.6102
66	79	236	249	71.4271	660	782	2364	2490	71.6871
67	83	235	249	70.5501	670	821	2354	2493	70.7746
68	87	234	249	69.6274	680	859	2344	2496	69.8719
69	90	232	249	68.7452	690	896	2332	2498	68.9776
70	94	231	249	67.8298	700	933	2319	2499	68.0902
71	98	230	250	66.9820	710	969	2305	2500	67.2078
72	101	228	249	66.0857	720	1004	2290	2500	66.3291
73	105	226	249	65.2166	730	1038	2274	2500	65.4531
74	108	225	249	64.3362	740	1073	2256	2498	64.5778
75	111	223	249	63.5197	750	1106	2238	2497	63.7050
76	115	221	249	62.5774	760	1139	2219	2494	62.8269
77	118	219	249	61.7404	770	1172	2199	2492	61.9480
78	121	217	248	60.8413	780	1204	2178	2488	61.0645
79	124	214	248	59.9226	790	1236	2156	2485	60.1771
80	127	212	247	59.0789	800	1267	2132	2480	59.2818
81	130	210	247	58.1654	810	1298	2108	2476	58.3788
82	133	207	246	57.2249	820	1329	2083	2470	57.4650
83	136	205	246	56.3254	830	1359	2056	2465	56.5425
84	139	202	245	55.3500	840	1389	2028	2458	55.6028
85	142	199	245	54.4148	850	1418	2000	2451	54.6503
86	145	196	244	53.5134	860	1448	1969	2444	53.6804
87	148	193	243	52.4794	870	1477	1938	2436	52.6928
88	151	189	242	51.4520	880	1505	1905	2428	51.6811
89	154	186	241	50.4157	890	1534	1870	2419	50.6451
90	156	182	240	49.3479	900	1562	1834	2409	49.5832
91	159	178	239	48.2219	910	1590	1796	2399	48.4847
92	162	174	238	47.1092	920	1618	1756	2388	47.3480
93	165	170	237	45.9209	930	1645	1714	2376	46.1707
94	167	166	236	44.7610	940	1673	1669	2363	44.9378
95	170	161	234	43.4198	950	1700	1621	2349	43.6472
96	173	156	233	42.0506	960	1727	1570	2334	42.2721
97	176	150	231	40.5018	970	1754	1514	2317	40.7983
98	178	144	229	38.9156	980	1780	1451	2297	39.1832
99	180	137	227	37.2242	990	1807	1379	2273	37.3494
100	183	128	223	34.9781	1000	1832	1280	2235	34.9415

Here are the graphs of the preceding returns. Observe the near linear slope. There is a slight arc to the slope that appears in both returns and both graphs.



Here we have the third program for scanning more or less each an every cubic unit of “solid” matter within a hollow world. It measures gravitational attraction both “vertical” and “horizontal.” The model used for the program is actually a half-sphere that has been hollowed out. The half-sphere model permits a consideration of the “horizontal” compressional attraction of gravity that opposes itself. The program code shown here has been specifically adjusted for applications outside the hollow world, i.e. “outer space.”

```
  REM LIBERTY BASIC v4.03
  REM HollowWorld03.bas

  REM This program is only for calculating for a Hollow World
  REM outside the body.

  REM Define Variables (VAR):
  REM VAR   a = inner radius from center.
  REM VAR   b = center of scan from center.
  REM VAR   c = outer radius from center = 100 units.
  REM VAR   d = secondary radius of scan.
  REM VAR   p = pi = 3.14159.
  REM VAR xlo = x-component of intercept of VAR a and VAR b.
  REM VAR ylo = y-component of intercept of VAR a and VAR b.
  REM VAR mlo = slope of VAR d.
  REM VAR qlo = angle in radians between intercept of
  REM           Var a and VAR b with respect to center of VAR b.
  REM VAR xhi = x-component of intercept of VAR c and VAR b.
  REM VAR yhi = y-component of intercept of VAR c and VAR b.
  REM VAR mhi = slope of VAR d.
  REM VAR qhi = angle in radians between intercept of
  REM           Var c and VAR b with respect to center of VAR b.
  REM VAR qin = increment of scanning angle q necessary for one
  REM           unit along circumference in radians.
  REM VAR qsc = Angle of innermost scan in radians.
  REM VAR xgf = x-component of gravitational force.
  REM VAR ygf = y-component of gravitational force.
  REM VAR xsf = x-component of Sum of gravitational force.
  REM VAR xsf = y-component of Sum of gravitational force.
  REM VAR xst = x-component of Sub-Total of gravitational force.
  REM VAR yst = y-component of Sub-Total of gravitational force.
  REM VAR xtf = x-component of Total gravitational force.
  REM VAR ytf = y-component of Total gravitational force.
  REM VAR ngf = Normal gravitational force for hemisphere.
  REM VAR qtg = Angle of gravitational vector.
  REM VAR bli = Limit of sampling greater than 100.


  REM Load constants:
  LET   p = 3.14159

  REM Enter voluntary data:
INPUT "Enter outer radius (c)          : "; c
```

```
 INPUT "Enter inner radius (a) a<c      : "; a
 INPUT "Enter sampling limit (bli) bli>c: "; bli

   REM Establish outermost loop.
   LET xtg = 0
   LET ytg = 0
   LET b = c + 1
   WHILE b <= bli

   REM Initiate WHILE loop for VAR b radius:
   LET d = 1.0001
   LET xtf = 0
   LET ytf = 0
 WHILE d <= (b + c)

   REM Calculate parameters for scan next WHILE loop:

   LET qin = 1/d

    IF d < (c + b) AND d > (a + b)  THEN
   LET xlo = (d - b)
   LET ylo = 0
   LET mlo = 0
   LET qlo = 0
END IF

    IF d < (a + b) AND d > (b - a) THEN
   LET xlo = (d^2 - a^2 - b^2)/(2 * b)
   LET ylo = (a^2 - xlo^2)^(1/2)
   LET mlo = ylo/(xlo + b)
   LET qlo = acs((xlo + b)/d)
END IF

   IF d < (b - a) AND d > (b - c)  THEN
   LET xlo = (d - b)
   LET ylo = 0
   LET mlo = 0
   LET qlo = 0
END IF

    IF d = (b - c)  THEN
   LET xhi = (-1 * c)
   LET yhi = 0
   LET mhi = 0
   LET qhi = 0
END IF

   IF d = (b + c)  THEN
   LET xhi = (c)
   LET yhi = 0
   LET mhi = 0
   LET qhi = 0
END IF

    IF d > (b - c) AND d < (b + c) THEN
```

```
   LET xhi = (d^2 - c^2 - b^2)/(2 * b)
   LET yhi = (c^2 - xhi^2)^(1/2)
   LET mhi = yhi/(xhi + b)
   LET qhi = acs((xhi + b)/d)
END IF

   REM Establish inner WHILE loop:
   LET qsc = qlo
   LET xsf = 0
   LET ysf = 0
 WHILE qsc <= qhi

   REM Do innermost calculations:
   LET xgf =  (cos(qsc))/(d^2)   *   (p * d * sin(qsc))
   LET ygf =  (sin(qsc))/(d^2)   *   (2 * d * sin(qsc))

   REM Close out inner WHILE loop:
   LET xsf = xsf + xgf
   LET ysf = ysf + ygf
   LET qsc = qsc + qin
   LET xst = xsf
   LET yst = ysf
 WEND

   REM Add subtotal gravitational forces
   LET xtf = xtf + xst
   LET ytf = ytf + yst

   REM Close out WHILE loop for VAR b radius:
   LET d = d + 1
  WEND


  LET qtg = acs(xtf/((xtf^2 + ytf^2)^0.5)) * (180/p)
  LET ngf = (xtf^2 + ytf^2)^0.5

 PRINT using("####",b);
 PRINT using("#########",xtf);
 PRINT using("#########",ytf);
 PRINT using("#########",ngf);
 PRINT using("#####.####",qtg)

   REM Close out first WHILE loop.
   LET b = b + 1
  WEND

   REM End program:
   END
```

Here are two more sample runs using the preceding program. They are continuations of the preceding runs. The “quick run” required but a matter of seconds. The “detailed run took” about 4.5 hours.

Quick Run					Detailed Run				
Enter outer radius (c) : 100					Enter outer radius (c) : 1000				
Enter inner radius (a) a<c : 50					Enter inner radius (a) a<c : 500				
Enter sampling iimit (bli) bli>c: 200					Enter sampling iimit (bli) bli>c: 2000				
d	xtf	ytf	ngf	qtg	d	xtf	ytf	ngf	qtg
101	180	119	216	33.4220	1010	1797	1183	2151	33.3533
102	177	112	209	32.3071	1020	1762	1113	2084	32.2823
103	173	106	203	31.3910	1030	1728	1054	2024	31.3929
104	170	101	198	30.6148	1040	1695	1003	1969	30.6120
105	167	96	192	29.8791	1050	1663	957	1918	29.9116
106	163	91	187	29.2162	1060	1632	915	1870	29.2716
107	160	87	183	28.6304	1070	1601	876	1825	28.6793
108	158	84	179	28.0942	1080	1572	840	1782	28.1285
109	155	81	175	27.5757	1090	1543	807	1741	27.6117
110	152	78	171	27.0985	1100	1515	776	1702	27.1254
111	149	75	167	26.6286	1110	1488	747	1665	26.6654
112	147	72	163	26.1806	1120	1462	720	1629	26.2287
113	144	69	160	25.7470	1130	1436	694	1595	25.8126
114	141	67	157	25.3695	1140	1411	670	1562	25.4149
115	139	65	153	24.9976	1150	1386	648	1530	25.0357
116	137	63	150	24.6500	1160	1362	626	1499	24.6707
117	135	61	148	24.2928	1170	1339	605	1470	24.3223
118	132	59	145	23.9494	1180	1317	586	1441	23.9855
119	130	57	142	23.6034	1190	1295	567	1414	23.6617
120	128	55	139	23.3067	1200	1273	550	1387	23.3491
121	126	53	137	23.0214	1210	1252	533	1361	23.0467
122	124	52	134	22.7268	1220	1232	517	1336	22.7559
123	122	50	132	22.4368	1230	1212	501	1311	22.4728
124	120	49	129	22.1504	1240	1193	487	1288	22.2003
125	118	47	127	21.8734	1250	1174	473	1265	21.9353
126	116	46	125	21.6054	1260	1155	459	1243	21.6777
127	114	45	122	21.3744	1270	1137	446	1221	21.4282
128	113	44	121	21.1527	1280	1119	434	1200	21.1852
129	111	42	119	20.9120	1290	1102	422	1180	20.9496
130	109	41	117	20.6758	1300	1085	410	1160	20.7195
131	107	40	115	20.4477	1310	1069	399	1141	20.4968
132	106	39	113	20.2159	1320	1052	389	1122	20.2784
133	104	38	111	20.0128	1330	1037	379	1104	20.0670
134	103	37	109	19.8157	1340	1021	369	1086	19.8597
135	101	36	107	19.6111	1350	1006	359	1069	19.6587
136	100	35	106	19.4128	1360	991	350	1052	19.4610
137	98	34	104	19.2119	1370	977	342	1035	19.2685
138	97	33	102	19.0177	1380	963	333	1019	19.0807
139	95	33	101	18.8335	1390	949	325	1003	18.8963
140	94	32	99	18.6574	1400	936	317	988	18.7175
141	93	31	98	18.4890	1410	922	309	973	18.5416
142	91	30	96	18.3213	1420	909	302	958	18.3702
143	90	30	95	18.1477	1430	897	295	944	18.2020
144	89	29	94	17.9796	1440	884	288	930	18.0372
145	88	28	92	17.8146	1450	872	281	917	17.8761
146	87	28	91	17.6453	1460	860	275	903	17.7186
147	85	27	89	17.4858	1470	849	269	890	17.5635
148	84	26	88	17.3524	1480	837	263	877	17.4114
149	83	26	87	17.2051	1490	826	257	865	17.2634
150	82	25	86	17.0614	1500	815	251	853	17.1176

Quick Run (cont.)

Enter outer radius (c)   : 100
Enter inner radius (a) a<c   : 50
Enter sampling iimit (bli) bli>c: 200

d	xtf	ytf	ngf	qtg
151	81	25	85	16.9196
152	80	24	83	16.7707
153	79	24	82	16.6267
154	78	23	81	16.4849
155	77	23	80	16.3480
156	76	22	79	16.2319
157	75	22	78	16.1095
158	74	21	77	15.9800
159	73	21	76	15.8536
160	72	20	75	15.7319
161	71	20	74	15.6020
162	70	19	73	15.4802
163	69	19	72	15.3598
164	69	19	71	15.2460
165	68	18	70	15.1505
166	67	18	70	15.0405
167	66	18	69	14.9317
168	66	17	68	14.8259
169	65	17	67	14.7221
170	64	17	66	14.6157
171	63	16	65	14.5035
172	63	16	65	14.4010
173	62	16	64	14.2995
174	61	15	63	14.1978
175	60	15	62	14.1076
176	60	15	62	14.0144
177	59	15	61	13.9234
178	58	14	60	13.8306
179	58	14	60	13.7375
180	57	14	59	13.6483
181	57	14	58	13.5576
182	56	13	58	13.4695
183	55	13	57	13.3873
184	55	13	56	13.2978
185	54	13	56	13.2099
186	54	12	55	13.1299
187	53	12	54	13.0531
188	52	12	54	12.9723
189	52	12	53	12.8931
190	51	12	53	12.8142
191	51	11	52	12.7336
192	50	11	52	12.6587
193	50	11	51	12.5840
194	49	11	51	12.5052
195	49	11	50	12.4280
196	48	11	49	12.3522
197	48	10	49	12.2820
198	47	10	48	12.2133
199	47	10	48	12.1442
200	46	10	48	12.0814

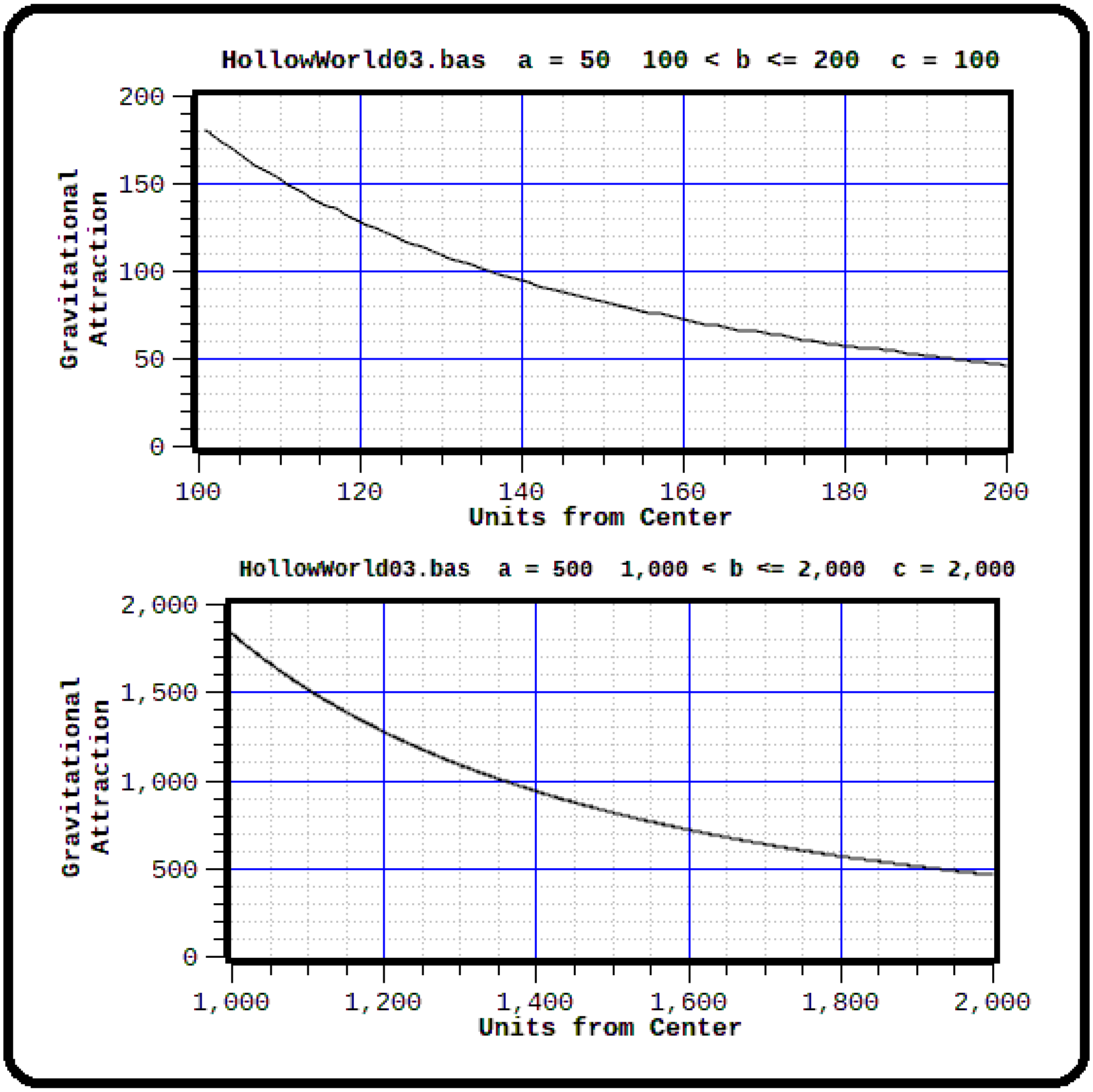
Detailed Run (cont.)

Enter outer radius (c)   : 1000
Enter inner radius (a) a<c   : 500
Enter sampling iimit (bli) bli>c: 2000

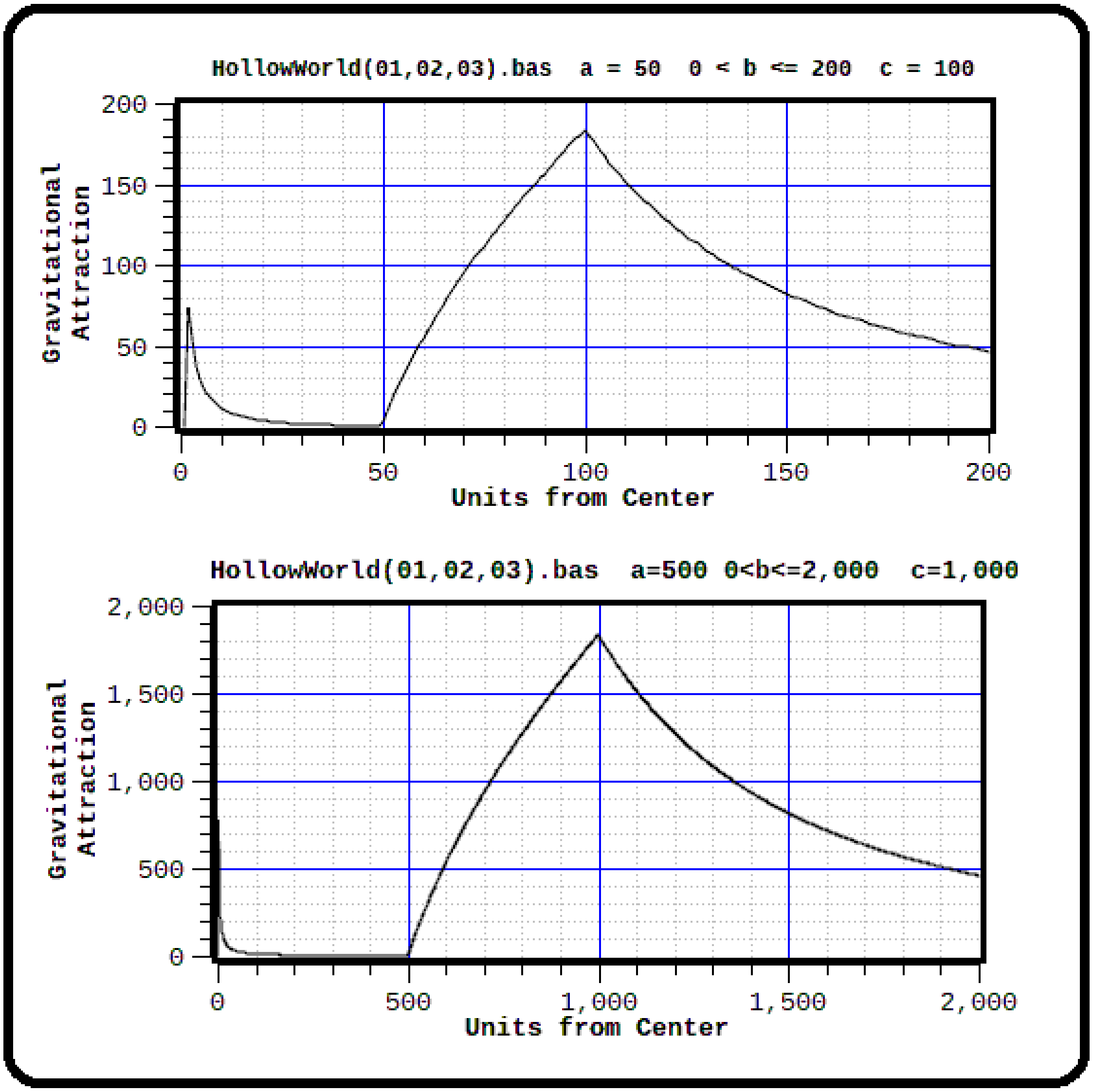
d	xtf	ytf	ngf	qtg
1510	804	246	841	16.9738
1520	794	240	829	16.8331
1530	784	235	818	16.6957
1540	773	230	807	16.5603
1550	763	225	796	16.4274
1560	754	220	785	16.2968
1570	744	216	775	16.1685
1580	735	211	765	16.0425
1590	726	207	754	15.9190
1600	717	203	745	15.7973
1610	708	199	735	15.6777
1620	699	195	726	15.5601
1630	690	191	716	15.4442
1640	682	187	707	15.3305
1650	674	183	698	15.2184
1660	666	180	690	15.1082
1670	658	176	681	14.9998
1680	650	173	673	14.8930
1690	642	170	664	14.7878
1700	635	166	656	14.6846
1710	627	163	648	14.5825
1720	620	160	640	14.4823
1730	613	157	633	14.3833
1740	606	154	625	14.2859
1750	599	151	618	14.1901
1760	592	149	611	14.0953
1770	586	146	604	14.0019
1780	579	143	597	13.9100
1790	573	141	590	13.8192
1800	566	138	583	13.7298
1810	560	136	576	13.6416
1820	554	134	570	13.5545
1830	548	131	563	13.4689
1840	542	129	557	13.3843
1850	536	127	551	13.3009
1860	530	125	545	13.2184
1870	525	122	539	13.1369
1880	519	120	533	13.0570
1890	514	118	527	12.9779
1900	508	116	521	12.8996
1910	503	114	516	12.8228
1920	498	113	510	12.7462
1930	493	111	505	12.6713
1940	488	109	500	12.5971
1950	483	107	494	12.5237
1960	478	105	489	12.4509
1970	473	104	484	12.3797
1980	468	102	479	12.3090
1990	463	101	474	12.2393
2000	459	99	469	12.1701

Observe that the attraction of gravity outside the hollow world varies inversely as the square of the distance with respect to the center of the hollow world.

Here are a pair of graphs of the preceding returns.



These two graphs put the entire sequence in perspective. The spike near the center is probably due an issue with the program code itself. However this is my no means certain. This is the reason that these six programs must be considered experimental.



Given that the outside trace is self-evident in the readily observable world, it follows that the interior projections are also true. Now any pressure from the outside will have no further inclination to “fall” further into the interior where there is no gravity to draw it in. Any attempt at a collapse will result in cross-ways pressure from inside the shell.

Let us now go back to the surface of the hollow world and find a better way not requiring a computer to do an extended scan of the imagined interior. We want to quickly find the surface gravity as an index for comparison. First, let us take a clue from an imagined hollow Earth whose innermost radius is zero (solid mass).

mas = mass of hollow world.

den = uniform density of mass of hollow world.

voi = volume interior of hollow world.

voe = volume of exterior of hollow world.

von = net volume of hollow world.

gc = 6.67 E-11 = gravitational constant.

a = interior radius of hollow world.

c = exterior radius of hollow world.

gro = outer surface gravity of hollow world.

$$gc := 6.67 \cdot 10^{-11} \qquad \frac{N \cdot m^2}{kg^2}$$

$$den := 5.519 \qquad a := 0 \qquad c := 6.371 \cdot 10^6$$

$$voi := \frac{4}{3} \cdot \pi \cdot a^3 \qquad voi = 0$$

$$voe := \frac{4}{3} \cdot \pi \cdot c^3 \qquad voe = 1.083 \times 10^{21}$$

$$von := voe - voi \qquad von = 1.083 \times 10^{21}$$

$$mas := 1000 \cdot von \cdot den \qquad mas = 5.978 \times 10^{24}$$

$$gro := gc \cdot \frac{mas}{c^2} \qquad gro = 9.824$$

The equation for [gro] assumes that the mass of a dropped object on the surface has an insignificant mass with respect to the main body. The mass is given in kilograms. The gravitational constant [gc] is a “fudge factor” to make the result come out in meters per second squared. Linear measures are in meters.

Computer programs are most often used for doing “bad math.” “Good Math” may be represented by the use of straight forward one-time equations and formulas. The calculus is a prime example of “good math.” “Good math” is also evident in trigonometry where the angles are given in radians and not converted to decimal notation, (with certain exceptions). Bad math is evidenced by the need for repeated feedback loops. Pi (π), the trigonometric functions, and the logarithmic functions are all solved by approximations using feedback loops of infinite series. This is why a good mathematician never actually resolves these functions until they have been reduced to an absolute minimum in number.

Now let us imagine an ideal imaginary hollow world in the real universe. That is to say that the shell is of a uniform density and the interior is in a vacuous state.

What we need to calculate is a “gravitational constant” that will “fudge” the return with respect to our scanning program so that the final result will agree with the real self-evident rate of acceleration due to gravity on the surface.

The following two cases represent the two examples that we have been looking at all along. The numerator represents the mass of the hollow sphere assuming a reference density of one. The 100^2 or the 1000^2 in the denominator represents the square of the exterior radius. The [2] in the denominator divides the result by two because the program only scans a hemisphere. Observe how the result agrees perfectly with the scanning program.

$$\frac{\frac{4}{3}\cdot\pi\cdot\left(100^3-50^3\right)}{2\cdot 100^2}=183.26 \qquad \frac{\frac{4}{3}\cdot\pi\cdot\left(1000^3-500^3\right)}{2\cdot 1000^2}=1832.596$$

Let us now construct a gravitational constant for our program.

gro = self-evident outer surface gravity of hollow world.

a = interior radius of hollow world.

c = exterior radius of hollow world.

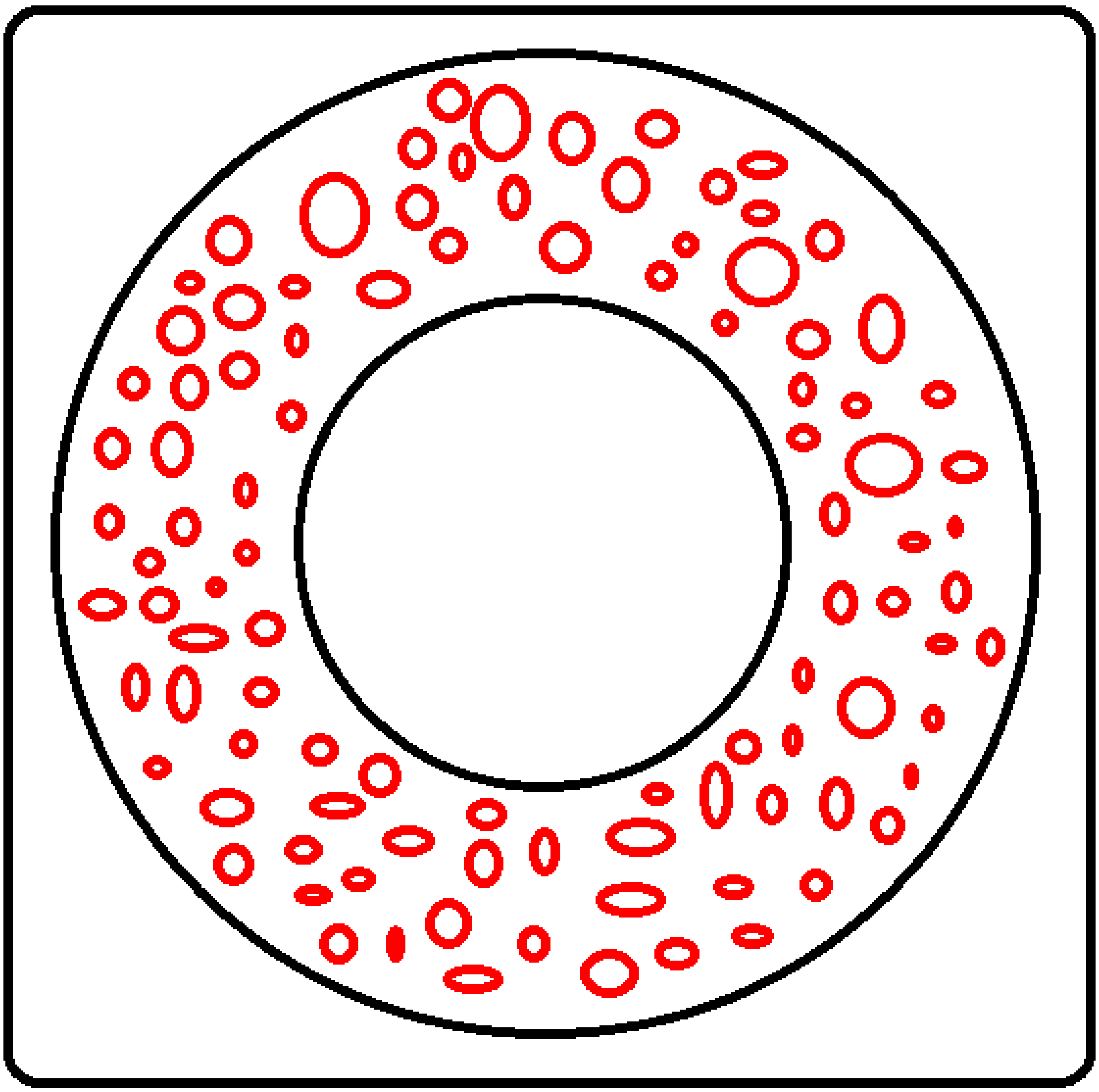
gc = gravitational constant

Check

$$a := 50 \quad c := 100 \quad gro := 5 \quad gc := \frac{gro}{\frac{\frac{4}{3}\cdot\pi\cdot\left(c^3-a^3\right)}{2\cdot c^2}} \quad gc = 0.027 \quad \boxed{gc\cdot\frac{\frac{4}{3}\cdot\pi\cdot\left(c^3-a^3\right)}{2\cdot c^2}=5}$$

Natural Cavities within a Hollow World

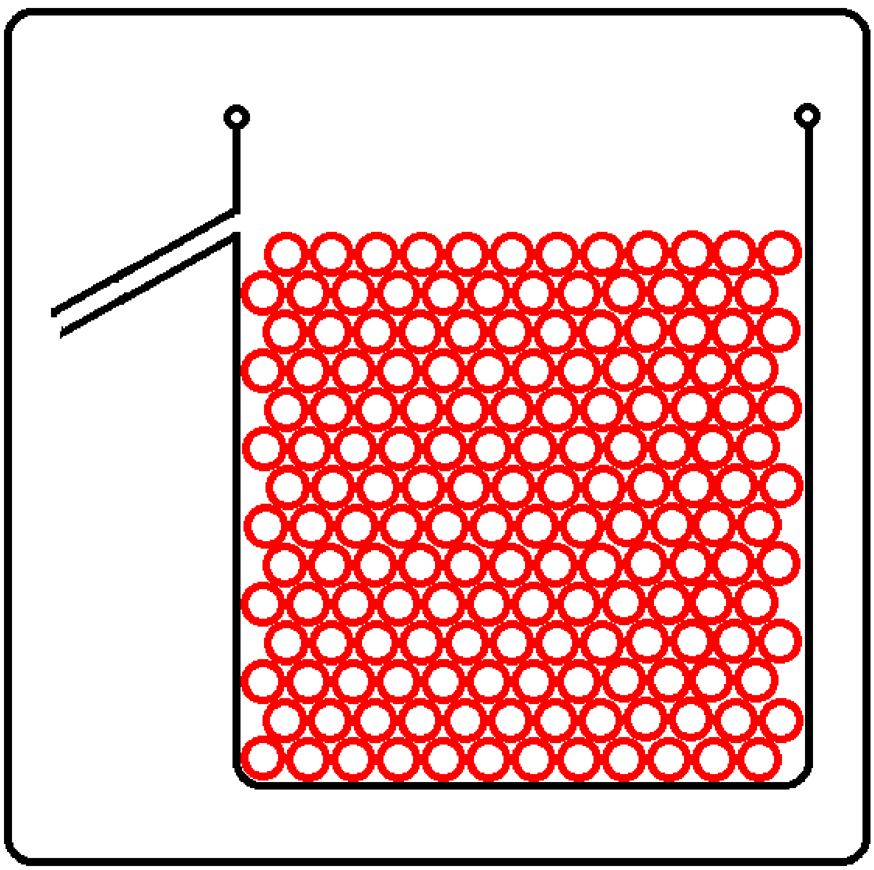
An Auxiliary theory of the shell of a Hollow World being filled with interconnecting vacuities.



This theory was inspired by a curious experience common to post-hole diggers and grave diggers. When a hole is dug, an object placed in the hole, and the hole is refilled and tamped down; all of the soil that was removed will just fill the earth to level without any left over.

The suggests a principle from chaos theory. The Earth that we walk upon is not solid but porous. The following two experiments were conducted to examine the natural degree of porosity.

A 250 ml beaker was first weighed, then weighed again filled with water to the imprecise 200 ml line. The water was then drained out and the beaker was filled to the imprecise 200 ml line with an aggregate an and weighed. Finally, the beaker with the aggregate was filled to the imprecise 200 ml with water and weighed. All four weights were recorded.



Next is a simple computer program written to analyze the results of the foregoing experiments.

```
  REM LIBERTY BASIC v4.03 program.
  REM Chaos01.bas

  REM Define variables:
  REM Mass is expressed as grams (g).
  REM Volume is expressed as milliliters (ml) or cubic centimeters (cm^3).
  REM VAR a = Mass of Beaker.
  REM VAR b = Mass of Beaker + Full Water.
  REM VAR c = Mass of Beaker + Full Aggregate.
  REM VAR d = Mass of Beaker + Full Aggregate + Fill Water.
  REM VAR e = Volume of Full Beaker.
  REM VAR f = Volume of Fill Water.
  REM VAR h = Proportion of Volume of Fill Water to Volume of Full Water.
  REM VAR i = Density of Aggregate as grams per milliliter (g/ml).

  REM Enter Experimental Data:
INPUT "Enter mass of empty beaker in grams (g)                : "; a
INPUT "Enter mass of beaker full of water in grams (g)        : "; b
INPUT "Enter mass of beaker filled with aggregate in grams (g): "; c
INPUT "Enter mass of Beaker + Aggregate + Water in grams (g)  : "; d

REM Clear Screen
  CLS

  REM Calculate Mass of Full Water as Var e:
  LET e = b - a

  REM Calculate Mass of Fill Water as Var f:
  LET f = d - c

  REM Calculate Proportion of mass of Fill Fater to Full Water as Var h:
  LET h = f/e

  REM Calculate Density of Aggregate as Var i.
  LET i = (c-a)/(e-f)

  REM Print out recap and return:
PRINT "Mass of Beaker ------------------------------ "; using("###.###",a); " grams."
PRINT "Mass of Beaker + Full Water ------------------ "; using("###.###",b); " grams."
PRINT "Mass of Beaker + Aggregate ------------------- "; using("###.###",c); " grams."
PRINT "Mass of Beaker + Aggregate + Fill Water ------ "; using("###.###",d); " grams."
PRINT "Volume of Beaker ---------------------------- "; using("###.###",e); " ml."
PRINT "Volume of Cavities -------------------------- "; using("###.###",f); " ml."
PRINT "Proportionate Volume of Cavities to Volume --- "; using("###.###",h)
PRINT "Density of Aggregate ------------------------- "; using("###.###",i); " g/ml."
```

Here are the results from two experiments.

Experiment 20240209A:

Aggregate: 47 Glass Marbles 0.060” to 0.65” diameter.

Mass of Beaker ------------------------------- 114.200 grams.

Mass of Beaker + Full Water ------------------ 300.000 grams.

Mass of Beaker + Aggregate ------------------- 363.700 grams.

Mass of Beaker + Aggregate + Fill Water ------ 451.400 grams.

Volume of Beaker ----------------------------- 185.800 ml.

Volume of Cavities -------------------------- 87.700 ml.

Proportionate Volume of Cavities to Volume ---   0.472

Density of Aggregate ------------------------   2.543 g/ml.

Observation: Water percolated readily through aggregate.

Experiment 20240209B:

Aggregate: Purple sand, probably crushed glass, very fine.

Mass of Beaker ------------------------------- 114.200 grams.

Mass of Beaker + Full Water ------------------ 300.000 grams.

Mass of Beaker + Aggregate ------------------- 379.400 grams.

Mass of Beaker + Aggregate + Fill Water ------ 466.300 grams.

Volume of Beaker ----------------------------- 185.800 ml.

Volume of Cavities -------------------------- 86.900 ml.

Proportionate Volume of Cavities to Volume ---   0.468

Density of Aggregate ------------------------   2.681 g/ml.

Observation: Water percolated slowly through aggregate. Blew out air bubbles.

Note: The same beaker was used in both experiments.

When we walk upon a sandy beach our weight presses the edges of the grains of sand where they meet and limit the contraction. The grains of sand are never perfectly uniform. Their various sizes and shapes interfere with one-another resulting in non-solid pockets. As the preceding experiments have indicated, these “pockets” can occupy up to 40% of the observed volume.

Nature abhors a vacuum. Even though more solid matter cannot enter the space between the aggregate, gasses may readily enter but fluids only can enter if the gasses are expelled. The most common fluid is water. It the water filling the vacancies in the soil that permits our agriculture.

There is always resistance, At great depths the fluid flow through the aggregate will become wholly blocked. This will allow for the formation of great cavities within the Earth.

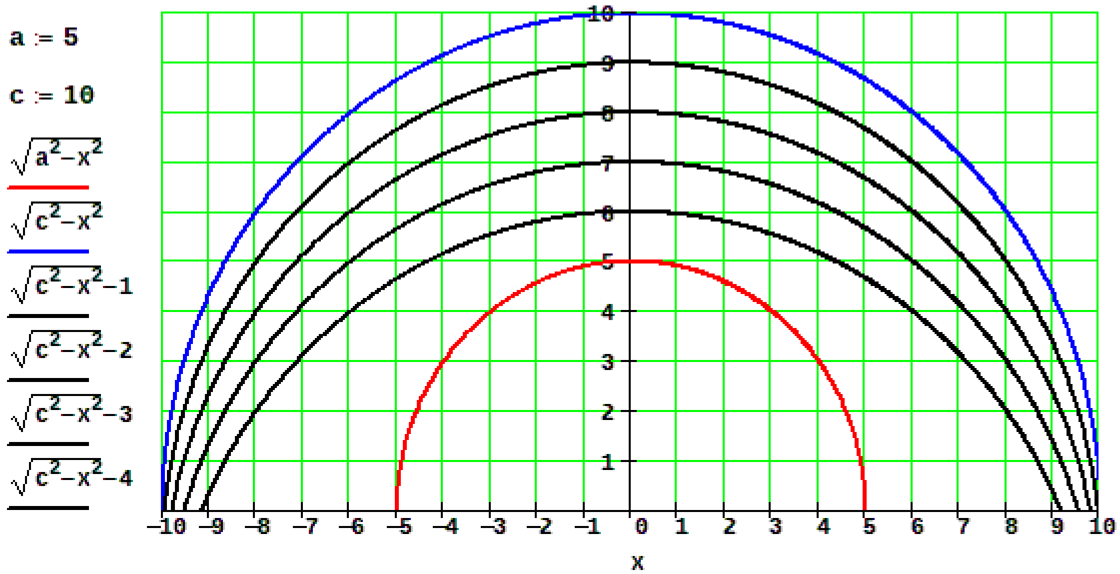
A cave may only collapse from the roof. However, as the roof of the cave collapses two things happen. The first is that the floor of the cave rises and becomes more level while the roof of the cave recedes upward forming a sharper angle. The second is that recession and sharpening of the angle of the roof has a limit that will be ultimately met. The volume of the cave remains unchanged. However, if the receding roof of the cave breaks through to the surface before the roof has stabilized and the entire system will collapse due to pressure from the sides. This latter has happened frequently leaving only the deep caves sealed up deep beneath the surface. Thus, this late in the course of natural evolution, only the deep caverns remain stable and interconnected. These deep interconnected caverns are generally not accessible from the surface.

Within the shell of a hollow world, the inclination of the roof of the great caverns to collapse is generally reduced in proportion to the relative depth through the shell while the cross-ways pressure that locks up the material is increasing.

Here is a curiosity. It is easily possible for the volume of the vacuous cavities within the shell of a hollow world to exceed the vacuous cavity in the interior of the hollow world. In such a case, the surface area would by far exceed the surface area of the interior.

Sheer Stress on the Surface and within the Shell of a Hollow World

A Celestial body is spinning about its polar axis. There will be a given surface velocity. This given surface velocity will be greatest at the equator and will be zero at the polar axis. This difference in velocity will result in three different effects.



The first effect will occur along the polar axis. Where the opposing solid masses meet along the polar axis, the tangent torque forces will be diametrically opposed to one another. This opposition will be the greatest at the equator and be reduced to zero at the poles. A ripping along the polar axis will occur resulting in a long open fissure throughout the length of the polar axis, but excluding the poles themselves. This effect will be the most pronounced in the earliest part of the formation of the Celestial body when the rate of rotation is at its greatest.

The second effect will occur in discreet layers with respect to the surface of the rotating Celestial body. An overlying mass will be moving faster than an underlying mass, howbeit in the same direction. Where this differential sheer force is great enough, a gravelly discontinuity will be formed. These discontinuities will be generally in the form of a football, (American, not European). These discontinuities will permit slippage and relief from the sheer forces.

The third effect will occur along the surface of the rotating sphere. With respect to the length of the polar axis, different latitudes will be traveling at different surface velocities. This too will result in a ripping and tearing sheer force. If the Celestial body has an outer atmosphere, this effect will be the most immediately pronounced at the poles and the least pronounced at the equator. On a longer time scale this same effect will cause the surface of the Celestial body at one particular latitude to tear away from other the surface of the other neighboring latitudes. At the poles this may result in a polar depression, (not to be confused with the psychological depression brought about by 6 months of darkness).

All three of these effects would have been the most pronounced in the earliest formation of the Celestial body when the rate of rotation was the highest along with a greater fluidity.

There is a fourth consideration. This consideration is a matter of natural evolution where nature follows the path of least resistance. For these arguments it will be logically and reasonably assumed that the mass of the shell remains constant.

As the hollow world is rotating about its polar axis, it is producing a sheer force between the outer and the inner radius. The sheer force is produced from the difference in the two velocities. Given that the mass must remain unchanged, a thinner shell would reduce thee difference in the two velocities. However, unless the density of the mass were to increase, which is highly unlikely, the outer radius must increase as well. Now when the inner radius seeks to increase, the outer radius must increase in order to maintain the same volume. However, the increase in the outer radius must be less than the increase in the inner radius. Thus, by natural evolution the rotating hollow world will seek to expand while thinning out the shell.

All of the evolutionary disturbances within a rotating hollow world will produce slippages which produce heat. A local slippage just beneath the surface can produce a local extreme heat and temperature that will cause the material to melt and be driven out to the surface. This process will bit by bit expand the outer radius of the hollow world while at the same time result in near surface vacancies which had formerly held the expelled materials.

Ideal Gas Pressure and Density within the Shell of a Hollow World

Nature abhors a vacuum. Within the interior of a hollow world and within the vacuities in the shell of a hollow world there will be gasses if any gasses are present in the mix. There will also be an overflow of the gasses surrounding the exterior as well.

This final section looks at the case where a vertical passage of one square meter is passed through the shell of the hollow world. This passage is filled with an ideal gas of a specific density at a temperature of 25ºC and a pressure of 100 KPa. It begins with a base pressure at the interior radius where the rate of acceleration due to gravity is zero and is tracked upwards to the surface in lengths of one kilometer.

The pascal is defined as the force of one kilogram of mass acting on one square meter of surface at a given rate of acceleration due to gravity. For example; On the surface of the Earth there is around 100 KPa of atmospheric pressure. When this is divided by an acceleration due to gravity of around 10 meters per second squared, the result is around 10,000 kilograms of mass of air per square meter overlying the surface of the Earth. If this were water at 1,000 kilograms per cubic meter, the Earth would be covered with water 10 meters (33 feet) deep.

A decrease in the pressure acting on an ideal gas will result in a proportionate decrease in the density of the ideal gas. The pressure will decrease with a rise in elevation.

A decrease in the absolute temperature acting on an ideal gas will result in a proportionate increase in the density of the ideal gas. For this section we will ignore this feature.

This section will go back to the program HollowWorld02.bas and modify it as HollowWorld04.bas. This new version will place a reasonable pressure of gas into the interior of the hollow world and measure it throughout the passage to the outer surface. This will a predictive program to see just how much of the internal atmosphere would be self-evident on the surface.

The mass of the gas would be quite minuscule relative to the overall solid mass and would result in very little alteration of the base assumptions.

Here is the modified program that I wrote to solve this problem. Because of the slight curvature in the changing rate of acceleration due to gravity this must be considered a three-body problem. Thus, the need for the computer.

The adjustment to the program is founded on the following considerations.

1. An initial air pressure for the bottom of the stack is entered in terms of [KPa] as VAR [pin]
2. A specific air density for an air pressure of 100 KPa at 25ºC is entered as VAR [pst].
3. A local air density is calculate by [(pin/100) x pst] as VAR [pga].
4. The surface rate of acceleration due to gravity m/s^2 is entered as VAR [gsu]
5. A gravitational constant for use in the program is calculated as VAR [gco].
6. The raw attraction of gravity from the program is adjusted with respect to the real surface gravity by the use of the calculated gravitational constant. This is expressed as meters per second squared. This is returned as VAR [gxa], VAR [gya] and VAR [gna]. We are mainly concerned here with VAR [gxa] representing the vertical rate of acceleration due to gravity in meters per second squared.
7. A column of air measuring 1 m wide x 1 m long x 1,000 m high is imagined. The mass and the vertical pressure are calculated using the local pressure with respect to the index pressure of 100 KPa.
8. A new density and a new pressure is established by subtracting the partial pressure of the block from the preceding pressure. There is also a new rate of acceleration due to gravity. These overwrite the former.
9. Because the pressure is expressed as KPa and the sectioned altitudes are expressed as Km, there is no need to actually multiply by 1,000.

```
REM LIBERTY BASIC v4.03
REM HollowWorld04.bas

REM This program is restricted to the shell area
REM of the hollow world. It has been modified from
REM HollowWorld02.bas to show an internal atmosphere.

REM Define Variables (VAR):
REM VAR   a = inner radius fom center.
REM VAR   b = center of scan from center.
REM VAR   c = outer radius from center = 100 units.
REM VAR   d = secondary radius of scan.
REM VAR   p = pi = 3.14159.
REM VAR xlo = x-component of intercept of VAR a and VAR b.
REM VAR ylo = y-component of intercept of VAR a and VAR b.
REM VAR mlo = slope of VAR d.
```

```
  REM VAR qlo = angle in radians between intercept of
  REM           Var a and VAR b with respect to center of VAR b.
  REM VAR xhi = x-component of intercept of VAR c and VAR b.
  REM VAR yhi = y-component of intercept of VAR c and VAR b.
  REM VAR mhi = slope of VAR d.
  REM VAR qhi = angle in radians between intercept of
  REM           Var c and VAR b with respect to center of VAR b.
  REM VAR qin = increment of scanning angle q neccessary for one
  REM           unit along circumference in radians.
  REM VAR qsc = Angle of innnermost scan in radians.
  REM VAR xgf = x-component of gravitational force.
  REM VAR ygf = y-component of gravitational force.
  REM VAR xsf = x-component of Sum of gravitational force.
  REM VAR xsf = y-component of Sum of gravitational force.
  REM VAR xst = x-component of Sub-Total of gravitational force.
  REM VAR yst = y-component of Sub-Total of gravitational force.
  REM VAR xtf = x-component of Total gravitational force.
  REM VAR ytf = y-component of Total gravitational force.
  REM VAR ngf = Normal gravitational force for hemisphere.
  REM VAR qtg = Angle of gravitational vector.
  REM VAR gsu = Surface gravity in m/s^2.                      'NEW
  REM VAR pst = Gas density at 25 C and 100 KPa.               'NEW
  REM VAR gco = Gravitational constant for program.            'NEW
  REM VAR gxa = x-coordinate rate of acceleration in m/s^2.    'NEW
  REM VAR gya = y-coordinate rate of acceleration in m/s^2.    'NEW
  REM VAR gna = Normal rate of acceleration in m/s^2.          'NEW
  REM VAR pin = Interior air pressure in KPa. (cycle).         'NEW
  REM VAR mat = Total mass of column of air in kg. (cycle).    'NEW
  REM VAR mas = Mass of air in 1 km section of column.         'NEW
  REM VAR pga = Gas density in kg/m^3 (cycle).                 'NEW
               '

  REM Load constants:
  LET   p = 3.14159

  REM Enter voluntary data:
INPUT "Enter outer radius (c) (km)                : "; c
INPUT "Enter inner radius (a) a<c (km)            : "; a
INPUT "Enter surface gravity (gsu) (m/s^2)        : "; gsu    'NEW
INPUT "Enter STP gas density (pst) (kg/m^3)       : "; pst    'NEW
INPUT "Enter interior air pressure (pin) (KPa)    : "; pin    'NEW

  REM calculate gravitational constant for program.           'NEW
  LET gco = gsu/(((4/3) * p * (c^3 - a^3))/(2 * c^2))         'NEW

  REM Establish outermost loop.
  LET xtg = 0
  LET ytg = 0
  LET   b = a
  LET mas = (pin/100) * pst                                   'NEW
  LET pga = (pin/100) * pst                                   ‘NEW

  WHILE b <= c
```

```
   REM Initiate WHILE loop for VAR b radius:
   LET d = 1.0001
   LET xtf = 0
   LET ytf = 0
 WHILE d <= (b + c)

   REM Calculate parameters for scan next WHILE loop:

   LET qin = 1/d

    IF d < (b - a) OR d > (b + a)  THEN
   LET xlo = (a - d)
   LET ylo = 0
   LET mlo = 0
   LET qlo = 0
END IF

    IF d > (b - a) AND d < (b + a) THEN
   LET xlo = (d^2 - a^2 - b^2)/(2 * b)
   LET ylo = (a^2 - xlo^2)^(1/2)
   LET mlo = ylo/(xlo + b)
   LET qlo = acs((xlo + b)/d)
END IF

    IF d <= (c - b) THEN
   LET xhi = (c - d)
   LET yhi = 0
   LET mhi = 0
   LET qhi = p
END IF

    IF d > (c - b) THEN
   LET xhi = (d^2 - c^2 - b^2)/(2 * b)
   LET yhi = (c^2 - xhi^2)^(1/2)
   LET mhi = yhi/(xhi + b)
   LET qhi = acs((xhi + b)/d)
END IF

   REM Establish inner WHILE loop:
   LET qsc = qlo
   LET xsf = 0
   LET ysf = 0
 WHILE qsc <= qhi

   REM Do innermost calculations:
   LET xgf =  (cos(qsc))/(d^2)   *   (p * d * sin(qsc))
   LET ygf =  (sin(qsc))/(d^2)   *   (2 * d * sin(qsc))

   REM Close out inner WHILE loop:
   LET xsf = xsf + xgf
   LET ysf = ysf + ygf
   LET qsc = qsc + qin
   LET xst = xsf
   LET yst = ysf
```

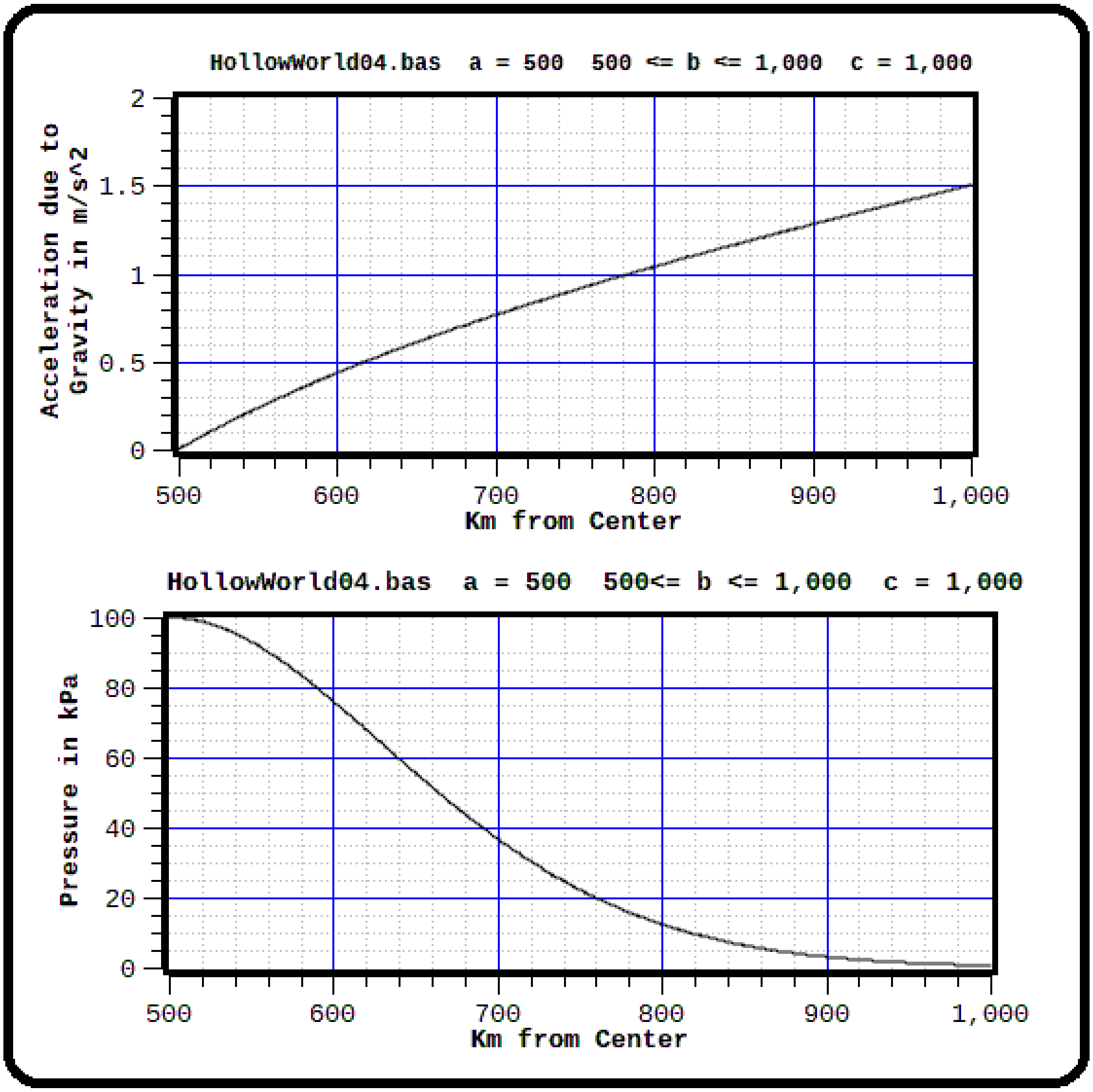
```
  WEND

    REM Add subtotal gravitational forces
    LET xtf = xtf + xst
    LET ytf = ytf + yst

    REM Close out WHILE loop for VAR b radius:
    LET d = d + 1
   WEND


   LET qtg = acs(xtf/((xtf^2 + ytf^2)^0.5)) * (180/p)
   LET ngf = (xtf^2 + ytf^2)^0.5

   REM Adjust [xtf], [ytf], and [ngf] for m/s^2.    'NEW
   LET gxa = xtf * gco                              'NEW
   LET gya = ytf * gco                              'NEW
   LET gna = ngf * gco                              'NEW


  PRINT using("####",b);
  PRINT using("####.####",gxa);                     'Changed
  PRINT using("####.####",gya);                     'Changed
  PRINT using("####.####",gna);                     'Changed
  PRINT using("####.####",qtg);
  PRINT using("####.####",pin);                     'NEW
  PRINT using("####.####",pga)                      'NEW

    REM Calculate pressure, density, and mass of air.'NEW
    LET pin = pin - (gxa * mas)                      'NEW
    LET mas = (pin/100) * pst                        'NEW
    LET pga = (pin/100) * pst                        'NEW


    REM Close out first WHILE loop.
    LET b = b + 1
   WEND

    REM End program:
    END
```

Here is a sample run using this program. It has been cropped to multiples of ten.

```
Enter outer radius (c) (km)                : 1000
Enter inner radius (a) a<c (km)            : 500
Enter surface gravity (gsu) (m/s^2)        : 1.5
Enter STP gas density (pst) (kg/m^3)       : 1.2
Enter interior air pressure (pin) (KPa)    : 100
  b    gx       gy       gn       q      Pressure   Density
 500   0.0019   1.7756   1.7756  89.9383 100.0000   1.2000
 510   0.0521   1.8311   1.8318  88.3713  99.7050   1.1965
 520   0.1005   1.8655   1.8682  86.9158  98.8229   1.1859
 530   0.1472   1.8909   1.8966  85.5492  97.3896   1.1687
```

540	0.1923	1.9102	1.9199	84.2517	95.4484	1.1454
550	0.2358	1.9251	1.9394	83.0159	93.0480	1.1166
560	0.2780	1.9363	1.9561	81.8300	90.2406	1.0829
570	0.3188	1.9446	1.9706	80.6885	87.0812	1.0450
580	0.3585	1.9503	1.9830	79.5856	83.6254	1.0035
590	0.3970	1.9539	1.9939	78.5162	79.9291	0.9591
600	0.4344	1.9556	2.0033	77.4759	76.0467	0.9126
610	0.4709	1.9556	2.0115	76.4624	72.0309	0.8644
620	0.5064	1.9540	2.0186	75.4711	67.9309	0.8152
630	0.5410	1.9511	2.0247	74.5009	63.7932	0.7655
640	0.5749	1.9468	2.0299	73.5482	59.6601	0.7159
650	0.6080	1.9413	2.0343	72.6102	55.5694	0.6668
660	0.6403	1.9347	2.0379	71.6871	51.5546	0.6187
670	0.6720	1.9270	2.0408	70.7746	47.6448	0.5717
680	0.7031	1.9183	2.0431	69.8719	43.8647	0.5264
690	0.7335	1.9086	2.0447	68.9776	40.2343	0.4828
700	0.7634	1.8981	2.0458	68.0902	36.7698	0.4412
710	0.7927	1.8866	2.0463	67.2078	33.4832	0.4018
720	0.8216	1.8742	2.0464	66.3291	30.3830	0.3646
730	0.8499	1.8610	2.0459	65.4531	27.4744	0.3297
740	0.8779	1.8470	2.0450	64.5778	24.7595	0.2971
750	0.9053	1.8322	2.0436	63.7050	22.2381	0.2669
760	0.9324	1.8164	2.0417	62.8269	19.9074	0.2389
770	0.9591	1.7999	2.0395	61.9480	17.7629	0.2132
780	0.9855	1.7825	2.0368	61.0645	15.7984	0.1896
790	1.0114	1.7644	2.0337	60.1771	14.0066	0.1681
800	1.0370	1.7453	2.0302	59.2818	12.3791	0.1485
810	1.0624	1.7255	2.0263	58.3788	10.9069	0.1309
820	1.0874	1.7047	2.0220	57.4650	9.5803	0.1150
830	1.1122	1.6830	2.0173	56.5425	8.3897	0.1007
840	1.1367	1.6603	2.0121	55.6028	7.3250	0.0879
850	1.1609	1.6366	2.0066	54.6503	6.3765	0.0765
860	1.1849	1.6119	2.0006	53.6804	5.5346	0.0664
870	1.2087	1.5862	1.9942	52.6928	4.7899	0.0575
880	1.2322	1.5592	1.9873	51.6811	4.1335	0.0496
890	1.2555	1.5309	1.9799	50.6451	3.5568	0.0427
900	1.2785	1.5014	1.9720	49.5832	3.0520	0.0366
910	1.3015	1.4703	1.9636	48.4847	2.6115	0.0313
920	1.3243	1.4375	1.9545	47.3480	2.2283	0.0267
930	1.3468	1.4030	1.9447	46.1707	1.8962	0.0228
940	1.3692	1.3662	1.9342	44.9378	1.6091	0.0193
950	1.3913	1.3271	1.9228	43.6472	1.3618	0.0163
960	1.4134	1.2848	1.9101	42.2721	1.1493	0.0138
970	1.4354	1.2389	1.8961	40.7983	0.9675	0.0116
980	1.4571	1.1876	1.8798	39.1832	0.8122	0.0097
990	1.4787	1.1285	1.8601	37.3494	0.6800	0.0082
1000	1.4996	1.0477	1.8294	34.9415	0.5679	0.0068

The following graphs were created from the preceding run of this program.



The preceding run and the associated graphs were for a body 2,000 Km (1,200 mi) in diameter. It had a hollow space in its interior of 1,000 Km (800 mi) in diameter. The hollow space in its interior had zero gravity. The self-evident exterior surface gravity was measured at 1.5 m/s^2. The gasses in the interior had a pressure of 100 KPa with a density of 1.2 kg/m^3, about the same as on the surface of the Earth.

Working up through the shell, the acceleration due to gravity rose from [0] to [1.5] meters per second squared. While the acceleration due to gravity was rising, the pressure dropped 176 fold from 100 KPa to 0,5679 KPa. In the process, the density of the air dropped from 1.2 Kg/m^3 176 fold to 0.0068 Kg/m^3.

Due to the surface constantly caving in on itself and sealing (diking) the interior from the surface, the residual pressure had no way out and lacked any force to break through to the surface.

If this world inhabited by men like ourselves, they could operate anywhere within the central cavity and the first 100 Km of the interconnected caverns.

Now the volume of the central cavity would be 523,598,000 cubic Km. The surface area of the central cavity would be 1,000,000 square Km.

This more or less concludes the basic theory of hollow worlds. It includes a lot of computer programs, the kind that require a great deal of time to run. This is the original intent of computers in the first place.

Now a word about the so-called “dark matter.” Dark matter is simply the matter that we may detect by its gravitational effects, but that we may never see visually. Some people in eminent positions attempt to explain the “dark matter” with wild theories about unknown exotic matter while ignoring the obvious.

When the Sun shines on a distant planet, the light received by the planet will vary inversely by the square of the distance. A portion of that light will be absorbed by the planet. The remainder will be reflected back into space as the albedo. The light that we receive from the albedo will vary as to the phase angle with respect to the Sun as well as inversely as the square of the distance between us and the planet. In essence, a planet far away from the Sun will generally vary in brightness somewhat less as the square of the radius of the body and inversely as the fourth root of the distance from the Sun. Anything past that distance of our range of detection will be “dark matter.”

With the naked eye, we can detect a star like our Sun up to about 40 light years. Anything past that is “dark.” That does not mean that they don’t exist. It just means that we cannot perceive them visually. The light of the self-luminous bodies (stars) will vary inversely as the square of the distance.

A telescope is a tool for improving the perceived resolution of a distant object. However, in the process of magnifying the image, the perception of light is reduced and other distortions damage the quality of the image. Furthermore, the telescope does not have the necessary lens to focus the infrared range and we do not have the natural perception to see into the infrared.

The point being is that the universe is far more vibrant and active than we are taught to imagine in our parochial little world!

The foregoing more or less acts as an introduction the controversial Spaceship Moon theory. It is included here because much of the “in-house” work has already been done.

Hypothesis of the Moon as a Spacecraft

The Spaceship Moon theory is a highly controversial hypothesis. So rather that get into the mares nest of the hopeless entanglement of politics, religion, science, and industry; I will attempt to begin by simply laying out the self-evident observations. Here is the baseline of real observed facts.

Taken from CRC Handbook of Chemistry and Physics, 62nd Edition (1981–1982):

Radius of body of Sun = 695,950 km.
Mass of Sun = 1.991 * 10^30 kg.
Surface Gravity of Sun = 273.72 m/s^2.
Mean rotation of Sun about Polar Axis = (00°) 2.125 * 10^6 s.
(30°) 2.290 * 10^6 s.
(60°) 2.678 * 10^6 s.
(90°) 2.851 * 10^6 s.

Radius of body of Earth = 6,371 km.
Mass of Earth = 5.979 * 10^24 kg.
Surface Gravity of Earth = 9.807 m/s^2.
Radius of orbit of Earth about Sun = 1.4957 * 10^8 km.
Rotation of Earth about Polar Axis = 8.6164 * 10^5 s.
Rotation of Earth about Sun = 3.1158 * 10^7 s.

Radius of body of Moon = 1,783 km.
Mass of Moon = 7.354 * 10^22 kg.
Surface Gravity of Moon = 1.62 m/s^2.
Radius of orbit of Moon about Earth = 384,400 km.
Rotation of Moon about Polar Axis = 2.3601 * 10^6 s.

Taken from Schaum’s Outlines, College Physics, Tenth Edition:

Law of Universal Gravitation:
Gravitational Constant (G): G = 6.667 * 10^-11 [(N * m^2)/(kg^2)].
F_G = G * (m1 * m2)/r^2
Mass (m1,m2) is in kilograms (kg). Radius of separation ins in meters (m).

Here are the basic givens and equations for the interrelations between the Sun, the Earth, and the Moon (Luna). The first row represents the identification of the given data. The second row represents the mass in kilograms of the respective bodies. The third row represents the radius in meters of the respective bodies. The fourth row represents the rate of acceleration due to gravity at the surface of the respective bodies. The fourth row data was not used in the associated equations, but will be used in the gravity and atmosphere computer program. The fifth row represents the respective distance in meters between the Earth and the Sun as well as the Mon and the Sun. The sixth row represents the gravitational constant. The calculated apparent diameters are both expressed in terms of minutes of a degree.

Sun (*s)	Earth (*e)	Moon (*l)	
$ms := 1.991 \cdot 10^{30}$	$me := 5.979 \cdot 10^{24}$	$ml := 7.354 \cdot 10^{22}$	[kg]
$rs := 6.9595 \cdot 10^{8}$	$re := 6.371 \cdot 10^{5}$	$rl := 1.783 \cdot 10^{6}$	[m]
$gs := 2.7372 \cdot 10^{2}$	$ge := 9.807 \cdot 10^{0}$	$gl := 1.62 \cdot 10^{0}$	$\frac{m}{s^2}$
$es := 1.4957 \cdot 10^{11}$	$el := 3.844 \cdot 10^{8}$		[m]
	$gc := 6.667 \cdot 10^{-11}$		$\frac{N \cdot m^2}{kg^2}$

Apparent Diameter of Sun from Earth $= 2 \cdot 60 \cdot \operatorname{atan}\left(\frac{rs}{es}\right) \cdot \left(\frac{180}{\pi}\right) = 31.991$

Apparent Diameter of Moon from Earth $= 2 \cdot 60 \cdot \operatorname{atan}\left(\frac{rl}{el}\right) \cdot \left(\frac{180}{\pi}\right) = 31.891$

Force of Gravity between Earth and Sun $= gc \cdot \left(\frac{ms \cdot me}{es^2}\right) = 3.548 \times 10^{22}$

Force of Gravity between Moon and Sun $= gc \cdot \left(\frac{ms \cdot ml}{es^2}\right) = 4.364 \times 10^{20}$

Force of Gravity between Moon and Earth $= gc \cdot \left(\frac{ml \cdot me}{el^2}\right) = 1.984 \times 10^{20}$

There are a number of self-evident observations that men have made about the Moon over the eons of time. There have been even more false assumptions and explanations, past and present, made by both the ignorant and by the ignorant that are revered as knowledgeable by the ignorant. Innocent ignorance is acceptable as a natural learning process. Guilty ignorance by choice paves the road to damnation.

Let us consider the following curious relationships of the Moon, the Earth, and the Sun, one to another.

1. The Solar Eclipse: Both the Moon and the Sun have the same apparent diameter. This is clearly shown in the preceding illustration. If a Solar Eclipse were to occur directly over the Equator, the shadow of totality would be focused at the precise center of the Earth.
2. The Lunar Eclipse: The totality of a Lunar Eclipse is a function of the difference in the radii of the Earth, one half the apparent angle of the Moon and the Sun, and the distance between the center of the Earth and the Center of the Moon. The radius of the Earth is 6,371 km. The radius of the Moon is 1,783 km. Because the tangent of one half of the apparent angle of the Sun and the Moon with respect to the distance between the Earth and the Moon is equal to the radius of the Moon, the radius of the shadow of the Earth at the distance of the Moon is equal to the difference of 4,588 km between the two radii. This is 2.5732 times greater than the radius of the Moon or 1.2866 times greater than the diameter of the Moon.
3. Close Rotation Periods of the Sun and the Moon: The Moon revolves about its polar axis in 27.3160 days. At the 0º latitude the Surface of the Sun appears to rotate about its polar axis in 24.5949 days. At 30º latitude representing the midpoint of the surface area of the Sun, the Sun appears to rotate about its polar axis in 26.5046 days. At 60º latitude the Sun appears to revolve about its Polar axis once every 30.9953 days. The average between 0º latitude and 60º latitude is 27.7951 days. The point of all this is that period of revolution of the Moon about its polar axis is within the apparent rate of the revolution of the Sun about its polar axis.
4. The Moon always keeps the same face to the earth: This is a controversial item. The “experts” of this age would have us believe that the Moon is tidally lock with the Earth. The “experts” seem to ignore the Sun. The calculations are demonstrated in the preceding illustration. The force of gravitational attraction between the Moon and the Sun is 2.2 times greater than the force of gravitational attraction between the Moon and the Earth. Furthermore, the force of gravitational attraction between the Earth and the

> Sun is 81.30 times greater than the force of gravitational attraction between the Moon and the Sun. If the idea of the Moon being tidally locked with the Earth had any merit, then the Moon should be tidally locked to the Sun instead. By the same merit the Earth should also be tidally locked to the Sun as well, in which case I would not be here to write these words and you would not be there to read these words!

In Celestial mechanics a triple alignment of Celestial bodies may only happen once, and that only briefly. At the time of the triple alignment, the three bodies will gravitationally pull towards one another and very slightly change their orbital parameters. The Moon-Earth-Sun relationship has been going on as far back as we can reasonably remember.

If the Moon were voluntarily placed around the Earth by unknown entities, then in consideration of the observed “coincidences”, such a placement would have been planned well ahead and for some definite purpose!

There are elementary principles in physics, known even by many people on the Earth, both today and in the distant past, by which entire worlds may voluntarily be moved about through space. Now it is far easier, and safer, to move an apparently airless planetoid such as the Moon as compared to a more massive body such as the Earth. We won’t even consider the issues with moving massive stars such as the Sun!!! Thus, we safely say that if the Moon were voluntarily delivered to the Earth, that only the Moon was involved with the voluntary action.

Now we have a serious issue. It is both a “spiritual” issue and a natural biological issue. This is not about any system of religion or belief. Your personal religion, your personal beliefs, and a $20 bill will buy you a cup of coffee at a truck-stop. Anyone else will pay $1.99 and the drivers will get it for free!

A perfect creator, knowing that it is a perfect creator, will engineer its creation to be slightly imperfect. An imperfect creator, knowing that it is an imperfect creator, will likewise engineer its creation to be slightly imperfect. In both cases, assuming that both the perfect creator and the imperfect creator are both competent, will vector their imperfections toward the natural evolutionary drift. This will be a matter of self-maintenance after the initial creationary process is completed.

All living creatures are created to be part of a greater whole. Each living creature flows through through through the other creations and the other creations flow through it. Each system of creation is specifically tailored to a particular environment. If any created life form leaves the environment for which it was tailored, it must carry with it a microcosm of its essential created partners. Failure to do this will ultimately result in death.

Populating the interior of a small hollow micro-world with integrated life forms will permit the vagabond space traveler to travel about without leaving home.

There is a “spiritual” side to the arguments. The physical body of Adam was created by the creators in their likeness and their image. However, the body was worthless with a voluntary consciousness to give it a sense of purpose and direction. This was supplied by God!!! This is the soul of a person, or an animal for that matter. This is the part that says “I am.” This is the part of the person that experiences the “material” world through the sensory environment of the physical senses. The “material” part of the created life must by necessity be corruptible as dictated by the natural evolution that must occur when the environment changes. It is like replacing an automobile with a boat during a flood. Unlike, the necessarily corruptible “material” body, the spirit continues to exist.

The hypothetical movers of planetoids surely are aware of all of the preceding arguments as well as more of their own. It would presumably not be a good thing to have a singular physical body perish in the depths of space far from its own kind. How would the spirit return home? The solution is simple. Take your home, your village, and your continent, along with its entire biome with you. The physical forms will hold the short-term biological memories and the mid-term biological memories that will be lost at death. The long-term memories will still be retained by the incorruptible “spirit.” Thus, the purposes that drove the hypothetical movers of planetoids will be maintained.

You who are reading this, please do not send me any hate mail if have I offended you. If you use this to start a new cult, I will not be joining, but I will accept the literature if it includes some good fantasy artwork, preferably done up in oils, I have a liking for fantasy oil paintings.

This all said, let us fill an interior space within the Moon with an initial air pressure. Due the length of the runs I have had to modify HollowWorld04.bas as HollowWorld05.bas to break it into sequential runs.

Here is the program as modified.

```
REM LIBERTY BASIC v4.03
REM HollowWorld05.bas

REM HollowWorld05.bas is a convenient modification
REM of HollowWorld04.bas. There was an issue regarding
REM the time required for long runs and computer
REM stability. The solution was to set a beginning and
REM ending limitation for the value of [b]. This
REM should permit farming out a run in discrete sections.
REM This modification will provide for convenience but
REM will also require more responsibility by the user.
REM When doing a long run piecemeal, it is vital that it
REM be done in tight sequence. The first four entries
REM will alweays be the same. The value of [VAR pin]
REM representing the initial interior air pressure must
REM be entered as the final air pressure of the preceding
REM runs of the sequential series of runs. Likewise, the
REM new beginning must take off at same value where
REM the preceding run ended.

REM This program is restricted to the shell area
REM of the hollow world. It has been modified from
REM HollowWorld02.bas to show an internal atmosphere.

REM Define Variables (VAR):
REM VAR   a = inner radius fom center.
REM VAR   b = center of scan from center.
REM VAR   c = outer radius from center = 100 units.
REM VAR   d = secondary radius of scan.
REM VAR   p = pi = 3.14159.
REM VAR xlo = x-component of intercept of VAR a and VAR b.
REM VAR ylo = y-component of intercept of VAR a and VAR b.
REM VAR mlo = slope of VAR d.
REM VAR qlo = angle in radians between intercept of
REM           Var a and VAR b with respect to center of VAR b.
REM VAR xhi = x-component of intercept of VAR c and VAR b.
REM VAR yhi = y-component of intercept of VAR c and VAR b.
REM VAR mhi = slope of VAR d.
REM VAR qhi = angle in radians between intercept of
REM           Var c and VAR b with respect to center of VAR b.
REM VAR qin = increment of scanning angle q neccessary for one
REM           unit along circumference in radians.
REM VAR qsc = Angle of innnermost scan in radians.
REM VAR xgf = x-component of gravitational force.
REM VAR ygf = y-component of gravitational force.
REM VAR xsf = x-component of Sum of gravitational force.
REM VAR xsf = y-component of Sum of gravitational force.
REM VAR xst = x-component of Sub-Total of gravitational force.
REM VAR yst = y-component of Sub-Total of gravitational force.
REM VAR xtf = x-component of Total gravitational force.
REM VAR ytf = y-component of Total gravitational force.
REM VAR ngf = Normal gravitational force for hemisphere.
REM VAR qtg = Angle of gravational vector.
REM VAR gsu = Surface gravity in m/s^2.                     'NEW
REM VAR pst = Gas density at 25 C and 100 KPa.              'NEW
```

```
   REM VAR gco = Gravitational constant for program.           'NEW
   REM VAR gxa = x-coordinate rate of acceleration in m/s^2.   'NEW
   REM VAR gya = y-coordinate rate of acceleration in m/s^2.   'NEW
   REM VAR gna = Normal rate of acceleration in m/s^2.         'NEW
   REM VAR pin = Interior air pressure in KPa. (cycle).        'NEW
   REM VAR mat = Total mass of column of air in kg. (cycle).   'NEW
   REM VAR mas = Mass of air in 1 km section of column.        'NEW
   REM VAR pga = Gas density in kg/m^3 (cycle).                'NEW
   REM VAR   u = Convenient ending value for VAR [b].          'NEWER
                '


   REM Load constants:
   LET   p = 3.14159

   REM Enter voluntary data:
 INPUT "Enter outer radius (c) (km)                 : "; c
 INPUT "Enter inner radius (a) a<c (km)             : "; a
 INPUT "Enter surface gravity (gsu) (m/s^2)         : "; gsu    'NEW
 INPUT "Enter STP gas density (pst) (kg/m^3)        : "; pst    'NEW
 INPUT "Enter interior air pressure (pin) (KPa)     : "; pin    'NEW
 INPUT "Enter beginning value of [b] (b) a<=b<=c    : "; b      'NEWER
 INPUT "Enter the ending value of [b](u) b<=u<=c    : "; u      'NEWER

   REM calculate gravitational constant for program.            'NEW
   LET gco = gsu/(((4/3) * p * (c^3 - a^3))/(2 * c^2))          'NEW

   REM Establish outermost loop.
   LET xtg = 0
   LET ytg = 0
'    LET   b = a                                                'REMOVED
   LET mas = (pin/100) * pst                                    'NEW
   LET pga = (pin/100) * pst
   LET pinx = pin

   WHILE b <= u                                                 'CHANGED


   REM Initiate WHILE loop for VAR b radius:
   LET d = 1.0001
   LET xtf = 0
   LET ytf = 0
 WHILE d <= (b + c)

   REM Calculate parameters for scan next WHILE loop:

   LET qin = 1/d

    IF d < (b - a) OR d > (b + a)  THEN
   LET xlo = (a - d)
   LET ylo = 0
   LET mlo = 0
   LET qlo = 0
END IF
```

```
    IF d > (b - a) AND d < (b + a) THEN
   LET xlo = (d^2 - a^2 - b^2)/(2 * b)
   LET ylo = (a^2 - xlo^2)^(1/2)
   LET mlo = ylo/(xlo + b)
   LET qlo = acs((xlo + b)/d)
END IF

    IF d <= (c - b) THEN
   LET xhi = (c - d)
   LET yhi = 0
   LET mhi = 0
   LET qhi = p
END IF

    IF d > (c - b) THEN
   LET xhi = (d^2 - c^2 - b^2)/(2 * b)
   LET yhi = (c^2 - xhi^2)^(1/2)
   LET mhi = yhi/(xhi + b)
   LET qhi = acs((xhi + b)/d)
END IF

   REM Establish inner WHILE loop:
   LET qsc = qlo
   LET xsf = 0
   LET ysf = 0
 WHILE qsc <= qhi

   REM Do innermost calculations:
   LET xgf =  (cos(qsc))/(d^2)   *   (p * d * sin(qsc))
   LET ygf =  (sin(qsc))/(d^2)   *   (2 * d * sin(qsc))

   REM Close out inner WHILE loop:
   LET xsf = xsf + xgf
   LET ysf = ysf + ygf
   LET qsc = qsc + qin
   LET xst = xsf
   LET yst = ysf
 WEND

   REM Add subtotal gravitational forces
   LET xtf = xtf + xst
   LET ytf = ytf + yst

   REM Close out WHILE loop for VAR b radius:
   LET d = d + 1
  WEND


  LET qtg = acs(xtf/((xtf^2 + ytf^2)^0.5)) * (180/p)
  LET ngf = (xtf^2 + ytf^2)^0.5

  REM Adjust [xtf], [ytf], and [ngf] for m/s^2.    'NEW
  LET gxa = xtf * gco                              'NEW
  LET gya = ytf * gco                              'NEW
  LET gna = ngf * gco                              'NEW
```

```
PRINT using("####",b);
PRINT using("####.####",gxa);                     'Changed
PRINT using("####.####",gya);                     'Changed
PRINT using("####.####",gna);                     'Changed
PRINT using("####.####",qtg);
PRINT using("####.####",pin);                     'NEW
PRINT using("####.####",pga)                      'NEW

  REM Calculate pressure, density, and mass of air.'NEW
  LET pin = pin - (gxa * mas)                      'NEW
  LET mas = (pin/100) * pst                        'NEW
  LET pga = (pin/100) * pst                        'NEW


  REM Close out first WHILE loop.
  LET b = b + 1
 WEND

  REM End program:
  END
```

This first run using the preceding modified program establishes a baseline representing a “solid” Moon. However, the “solid” simply refers to an empirically uniform state throughout. It does not consider the 20% to 40% volume occupied by deep caverns. The inhabitants of a “solid” Spaceship Moon would be using these deep caverns to their best advantage. This run presupposes that the deepest cavern at the center of the Moon will have the same atmospheric pressure and density as the surface of the Earth. Also presupposed is that the cavern system within the Moon is interconnected all the way to the surface by passages by passages permitting the free flow of gasses. The pressure at the surface will represent a maximum indicatory condition that may be measured. The following return has been cropped in multiples of 10 in order to reduce space.

```
outer radius (c) (km)                          : 1783
Enter inner radius (a) a<c (km)                : 0
Enter surface gravity (gsu) (m/s^2)            : 1.62
Enter STP gas density (pst) (kg/m^3)           : 1.2
Enter interior air pressure (pin) (KPa)        : 100
Enter beginning value of [b] (b) a<=b<=c       : 0
Enter the ending value of [b](u) b<=u<=c       : 1783
```

b	gx	gy	gn	q	Pressure	Density
0	-0.0002	2.4286	2.4286	90.0042	100.0000	1.2000
10	0.0089	2.4293	2.4293	89.7904	99.9538	1.1994
20	0.0180	2.4292	2.4293	89.5759	99.7982	1.1976
30	0.0271	2.4290	2.4292	89.3614	99.5341	1.1944
40	0.0362	2.4288	2.4291	89.1471	99.1625	1.1900
50	0.0453	2.4286	2.4290	88.9326	98.6846	1.1842
60	0.0543	2.4283	2.4289	88.7182	98.1019	1.1772
70	0.0634	2.4279	2.4287	88.5037	97.4162	1.1690
80	0.0725	2.4275	2.4286	88.2892	96.6299	1.1596
90	0.0816	2.4270	2.4284	88.0745	95.7454	1.1489
100	0.0907	2.4264	2.4281	87.8598	94.7654	1.1372
110	0.0998	2.4258	2.4279	87.6450	93.6932	1.1243
120	0.1089	2.4252	2.4276	87.4300	92.5321	1.1104
130	0.1179	2.4245	2.4273	87.2150	91.2856	1.0954
140	0.1270	2.4237	2.4270	87.0000	89.9576	1.0795
150	0.1361	2.4228	2.4267	86.7846	88.5522	1.0626
160	0.1452	2.4220	2.4263	86.5693	87.0737	1.0449
170	0.1543	2.4210	2.4259	86.3537	85.5263	1.0263
180	0.1634	2.4200	2.4255	86.1380	83.9148	1.0070
190	0.1725	2.4189	2.4251	85.9221	82.2437	0.9869
200	0.1815	2.4178	2.4246	85.7061	80.5178	0.9662
210	0.1906	2.4166	2.4241	85.4899	78.7421	0.9449
220	0.1997	2.4154	2.4236	85.2734	76.9215	0.9231
230	0.2088	2.4141	2.4231	85.0569	75.0608	0.9007
240	0.2179	2.4127	2.4225	84.8399	73.1652	0.8780
250	0.2270	2.4113	2.4220	84.6228	71.2395	0.8549
260	0.2361	2.4098	2.4214	84.4055	69.2887	0.8315
270	0.2451	2.4083	2.4207	84.1879	67.3177	0.8078
280	0.2542	2.4067	2.4201	83.9701	65.3313	0.7840
290	0.2633	2.4051	2.4194	83.7521	63.3342	0.7600

300	**0.2724**	**2.4034**	**2.4187**	**83.5337**	**61.3310**	**0.7360**
310	**0.2815**	**2.4016**	**2.4180**	**83.3151**	**59.3262**	**0.7119**
320	**0.2906**	**2.3998**	**2.4173**	**83.0961**	**57.3243**	**0.6879**
330	**0.2997**	**2.3979**	**2.4165**	**82.8770**	**55.3293**	**0.6640**
340	**0.3087**	**2.3959**	**2.4157**	**82.6572**	**53.3453**	**0.6401**
350	**0.3178**	**2.3939**	**2.4149**	**82.4374**	**51.3762**	**0.6165**
360	**0.3269**	**2.3918**	**2.4141**	**82.2172**	**49.4257**	**0.5931**
370	**0.3360**	**2.3897**	**2.4132**	**81.9966**	**47.4972**	**0.5700**
380	**0.3451**	**2.3875**	**2.4123**	**81.7756**	**45.5941**	**0.5471**
390	**0.3542**	**2.3853**	**2.4114**	**81.5543**	**43.7192**	**0.5246**
400	**0.3633**	**2.3830**	**2.4105**	**81.3326**	**41.8757**	**0.5025**
410	**0.3723**	**2.3806**	**2.4095**	**81.1105**	**40.0659**	**0.4808**
420	**0.3814**	**2.3781**	**2.4085**	**80.8881**	**38.2924**	**0.4595**
430	**0.3905**	**2.3756**	**2.4075**	**80.6651**	**36.5573**	**0.4387**
440	**0.3996**	**2.3731**	**2.4065**	**80.4417**	**34.8627**	**0.4184**
450	**0.4087**	**2.3705**	**2.4054**	**80.2181**	**33.2102**	**0.3985**
460	**0.4178**	**2.3678**	**2.4044**	**79.9937**	**31.6014**	**0.3792**
470	**0.4269**	**2.3650**	**2.4033**	**79.7692**	**30.0376**	**0.3605**
480	**0.4359**	**2.3622**	**2.4021**	**79.5439**	**28.5199**	**0.3422**
490	**0.4450**	**2.3594**	**2.4010**	**79.3183**	**27.0492**	**0.3246**
500	**0.4541**	**2.3564**	**2.3998**	**79.0921**	**25.6263**	**0.3075**
510	**0.4632**	**2.3534**	**2.3986**	**78.8655**	**24.2516**	**0.2910**
520	**0.4723**	**2.3504**	**2.3973**	**78.6382**	**22.9255**	**0.2751**
530	**0.4814**	**2.3472**	**2.3961**	**78.4106**	**21.6482**	**0.2598**
540	**0.4905**	**2.3441**	**2.3948**	**78.1822**	**20.4196**	**0.2450**
550	**0.4995**	**2.3408**	**2.3935**	**77.9534**	**19.2396**	**0.2309**
560	**0.5086**	**2.3375**	**2.3922**	**77.7241**	**18.1080**	**0.2173**
570	**0.5177**	**2.3341**	**2.3908**	**77.4940**	**17.0242**	**0.2043**
580	**0.5268**	**2.3306**	**2.3894**	**77.2635**	**15.9878**	**0.1919**
590	**0.5359**	**2.3271**	**2.3880**	**77.0321**	**14.9979**	**0.1800**
600	**0.5450**	**2.3236**	**2.3866**	**76.8003**	**14.0540**	**0.1686**
610	**0.5541**	**2.3199**	**2.3851**	**76.5678**	**13.1550**	**0.1579**
620	**0.5631**	**2.3162**	**2.3837**	**76.3345**	**12.3000**	**0.1476**
630	**0.5722**	**2.3124**	**2.3822**	**76.1008**	**11.4879**	**0.1379**
640	**0.5813**	**2.3086**	**2.3806**	**75.8662**	**10.7177**	**0.1286**
650	**0.5904**	**2.3046**	**2.3791**	**75.6310**	**9.9882**	**0.1199**
660	**0.5995**	**2.3007**	**2.3775**	**75.3951**	**9.2981**	**0.1116**
670	**0.6086**	**2.2966**	**2.3759**	**75.1582**	**8.6461**	**0.1038**
680	**0.6177**	**2.2925**	**2.3742**	**74.9208**	**8.0311**	**0.0964**
690	**0.6267**	**2.2883**	**2.3726**	**74.6826**	**7.4516**	**0.0894**
700	**0.6358**	**2.2840**	**2.3709**	**74.4436**	**6.9064**	**0.0829**
710	**0.6449**	**2.2797**	**2.3691**	**74.2040**	**6.3940**	**0.0767**
720	**0.6540**	**2.2753**	**2.3674**	**73.9633**	**5.9131**	**0.0710**
730	**0.6631**	**2.2708**	**2.3656**	**73.7218**	**5.4624**	**0.0655**
740	**0.6722**	**2.2662**	**2.3638**	**73.4795**	**5.0405**	**0.0605**
750	**0.6813**	**2.2616**	**2.3620**	**73.2365**	**4.6461**	**0.0558**
760	**0.6903**	**2.2569**	**2.3601**	**72.9922**	**4.2778**	**0.0513**
770	**0.6994**	**2.2522**	**2.3583**	**72.7475**	**3.9344**	**0.0472**
780	**0.7085**	**2.2473**	**2.3564**	**72.5013**	**3.6146**	**0.0434**
790	**0.7176**	**2.2424**	**2.3544**	**72.2545**	**3.3171**	**0.0398**
800	**0.7267**	**2.2374**	**2.3524**	**72.0066**	**3.0408**	**0.0365**
810	**0.7358**	**2.2323**	**2.3505**	**71.7580**	**2.7844**	**0.0334**
820	**0.7449**	**2.2272**	**2.3484**	**71.5081**	**2.5468**	**0.0306**
830	**0.7539**	**2.2220**	**2.3464**	**71.2573**	**2.3270**	**0.0279**
840	**0.7630**	**2.2167**	**2.3443**	**71.0051**	**2.1238**	**0.0255**

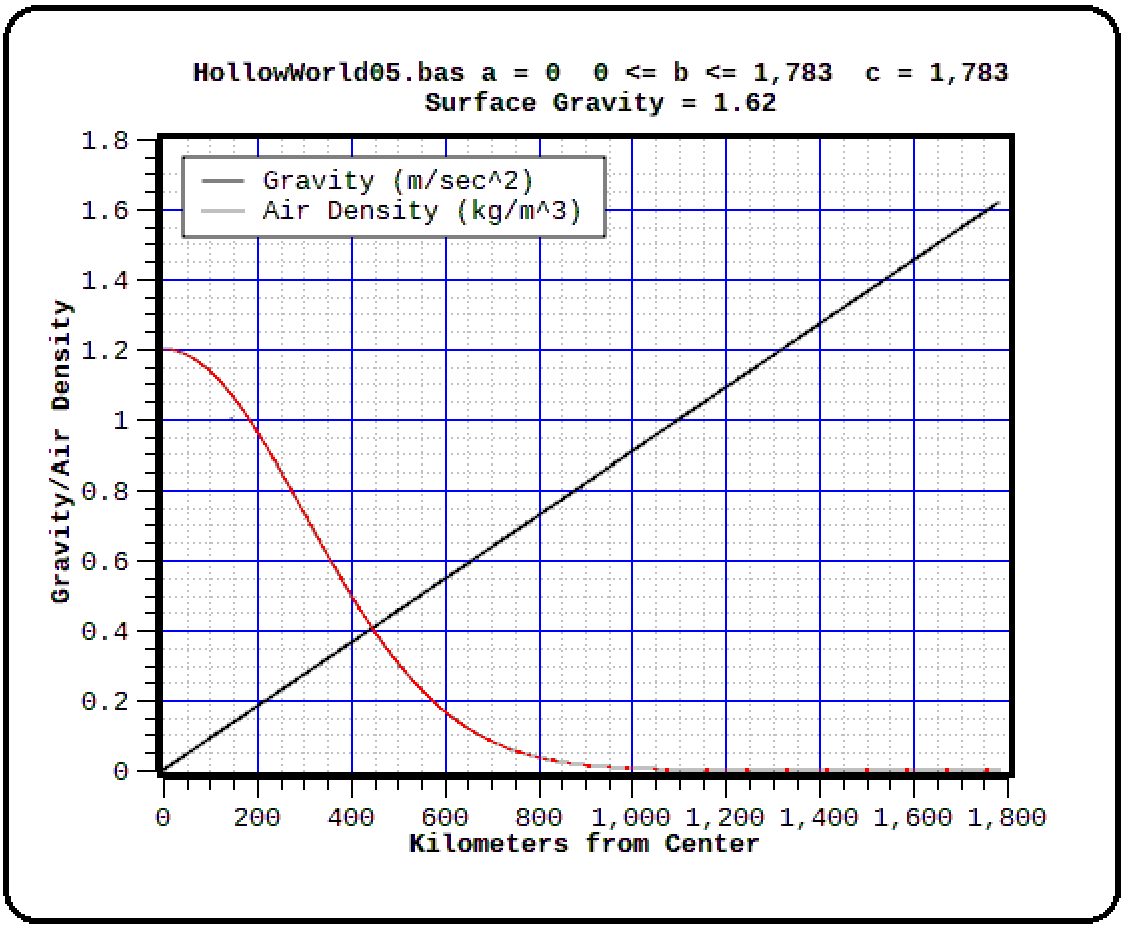
850	0.7721	2.2113	2.3422	70.7523	1.9362	0.0232
860	0.7812	2.2058	2.3401	70.4983	1.7632	0.0212
870	0.7903	2.2003	2.3379	70.2430	1.6039	0.0192
880	0.7994	2.1947	2.3357	69.9868	1.4574	0.0175
890	0.8085	2.1890	2.3335	69.7291	1.3228	0.0159
900	0.8175	2.1832	2.3312	69.4705	1.1994	0.0144
910	0.8266	2.1773	2.3290	69.2105	1.0862	0.0130
920	0.8357	2.1714	2.3266	68.9493	0.9827	0.0118
930	0.8448	2.1654	2.3243	68.6872	0.8880	0.0107
940	0.8539	2.1592	2.3219	68.4233	0.8016	0.0096
950	0.8630	2.1530	2.3196	68.1583	0.7228	0.0087
960	0.8721	2.1468	2.3171	67.8917	0.6510	0.0078
970	0.8812	2.1404	2.3147	67.6241	0.5857	0.0070
980	0.8902	2.1339	2.3122	67.3551	0.5264	0.0063
990	0.8993	2.1274	2.3096	67.0844	0.4725	0.0057
1000	0.9084	2.1207	2.3071	66.8123	0.4237	0.0051
1010	0.9175	2.1140	2.3045	66.5389	0.3795	0.0046
1020	0.9266	2.1072	2.3019	66.2637	0.3396	0.0041
1030	0.9357	2.1002	2.2992	65.9870	0.3035	0.0036
1040	0.9447	2.0932	2.2966	65.7087	0.2710	0.0033
1050	0.9538	2.0861	2.2938	65.4288	0.2416	0.0029
1060	0.9629	2.0789	2.2911	65.1470	0.2153	0.0026
1070	0.9720	2.0716	2.2883	64.8638	0.1915	0.0023
1080	0.9811	2.0642	2.2855	64.5789	0.1703	0.0020
1090	0.9902	2.0567	2.2826	64.2918	0.1512	0.0018
1100	0.9993	2.0491	2.2798	64.0032	0.1341	0.0016
1110	1.0083	2.0414	2.2768	63.7128	0.1188	0.0014
1120	1.0174	2.0336	2.2739	63.4203	0.1051	0.0013
1130	1.0265	2.0256	2.2709	63.1257	0.0929	0.0011
1140	1.0356	2.0176	2.2679	62.8295	0.0820	0.0010
1150	1.0447	2.0095	2.2648	62.5309	0.0724	0.0009
1160	1.0538	2.0012	2.2617	62.2301	0.0638	0.0008
1170	1.0629	1.9928	2.2586	61.9271	0.0561	0.0007
1180	1.0719	1.9844	2.2554	61.6224	0.0493	0.0006
1190	1.0810	1.9758	2.2522	61.3149	0.0433	0.0005
1200	1.0901	1.9671	2.2489	61.0055	0.0380	0.0005
1210	1.0992	1.9582	2.2456	60.6932	0.0333	0.0004
1220	1.1083	1.9493	2.2423	60.3788	0.0291	0.0003
1230	1.1174	1.9402	2.2389	60.0619	0.0255	0.0003
1240	1.1265	1.9310	2.2355	59.7425	0.0222	0.0003
1250	1.1355	1.9217	2.2321	59.4203	0.0194	0.0002
1260	1.1446	1.9122	2.2286	59.0953	0.0169	0.0002
1270	1.1537	1.9026	2.2251	58.7677	0.0147	0.0002
1280	1.1628	1.8929	2.2215	58.4371	0.0128	0.0002
1290	1.1719	1.8830	2.2179	58.1036	0.0111	0.0001
1300	1.1810	1.8730	2.2142	57.7670	0.0096	0.0001
1310	1.1901	1.8628	2.2105	57.4275	0.0084	0.0001
1320	1.1992	1.8525	2.2067	57.0844	0.0072	0.0001
1330	1.2082	1.8420	2.2029	56.7381	0.0063	0.0001
1340	1.2173	1.8314	2.1991	56.3886	0.0054	0.0001
1350	1.2264	1.8206	2.1952	56.0355	0.0047	0.0001
1360	1.2355	1.8097	2.1912	55.6787	0.0040	0.0000
1370	1.2446	1.7986	2.1872	55.3182	0.0035	0.0000
1380	1.2537	1.7874	2.1832	54.9538	0.0030	0.0000
1390	1.2628	1.7759	2.1791	54.5855	0.0026	0.0000

1400	**1.2718**	**1.7643**	**2.1749**	**54.2131**	**0.0022**	**0.0000**
1410	**1.2809**	**1.7525**	**2.1707**	**53.8363**	**0.0019**	**0.0000**
1420	**1.2900**	**1.7405**	**2.1664**	**53.4556**	**0.0016**	**0.0000**
1430	**1.2991**	**1.7283**	**2.1621**	**53.0687**	**0.0014**	**0.0000**
1440	**1.3082**	**1.7159**	**2.1577**	**52.6794**	**0.0012**	**0.0000**
1450	**1.3173**	**1.7033**	**2.1533**	**52.2840**	**0.0010**	**0.0000**
1460	**1.3263**	**1.6905**	**2.1487**	**51.8833**	**0.0009**	**0.0000**
1470	**1.3354**	**1.6775**	**2.1442**	**51.4772**	**0.0007**	**0.0000**
1480	**1.3445**	**1.6642**	**2.1395**	**51.0659**	**0.0006**	**0.0000**
1490	**1.3536**	**1.6508**	**2.1348**	**50.6485**	**0.0005**	**0.0000**
1500	**1.3627**	**1.6370**	**2.1300**	**50.2255**	**0.0004**	**0.0000**
1510	**1.3718**	**1.6230**	**2.1251**	**49.7958**	**0.0004**	**0.0000**
1520	**1.3809**	**1.6088**	**2.1202**	**49.3600**	**0.0003**	**0.0000**
1530	**1.3900**	**1.5943**	**2.1151**	**48.9170**	**0.0003**	**0.0000**
1540	**1.3990**	**1.5795**	**2.1100**	**48.4670**	**0.0002**	**0.0000**
1550	**1.4081**	**1.5644**	**2.1048**	**48.0093**	**0.0002**	**0.0000**
1560	**1.4172**	**1.5490**	**2.0995**	**47.5444**	**0.0002**	**0.0000**
1570	**1.4263**	**1.5333**	**2.0941**	**47.0703**	**0.0001**	**0.0000**
1580	**1.4354**	**1.5172**	**2.0886**	**46.5880**	**0.0001**	**0.0000**
1590	**1.4445**	**1.5008**	**2.0830**	**46.0956**	**0.0001**	**0.0000**
1600	**1.4535**	**1.4840**	**2.0773**	**45.5940**	**0.0001**	**0.0000**
1610	**1.4626**	**1.4668**	**2.0714**	**45.0811**	**0.0001**	**0.0000**
1620	**1.4717**	**1.4491**	**2.0654**	**44.5568**	**0.0001**	**0.0000**
1630	**1.4808**	**1.4311**	**2.0593**	**44.0215**	**0.0000**	**0.0000**
1640	**1.4899**	**1.4125**	**2.0530**	**43.4724**	**0.0000**	**0.0000**
1650	**1.4990**	**1.3934**	**2.0466**	**42.9096**	**0.0000**	**0.0000**
1660	**1.5081**	**1.3738**	**2.0400**	**42.3317**	**0.0000**	**0.0000**
1670	**1.5172**	**1.3535**	**2.0331**	**41.7365**	**0.0000**	**0.0000**
1680	**1.5263**	**1.3325**	**2.0261**	**41.1232**	**0.0000**	**0.0000**
1690	**1.5353**	**1.3108**	**2.0188**	**40.4900**	**0.0000**	**0.0000**
1700	**1.5444**	**1.2883**	**2.0112**	**39.8340**	**0.0000**	**0.0000**
1710	**1.5535**	**1.2649**	**2.0033**	**39.1539**	**0.0000**	**0.0000**
1720	**1.5626**	**1.2403**	**1.9950**	**38.4413**	**0.0000**	**0.0000**
1730	**1.5717**	**1.2146**	**1.9863**	**37.6970**	**0.0000**	**0.0000**
1740	**1.5808**	**1.1873**	**1.9770**	**36.9091**	**0.0000**	**0.0000**
1750	**1.5898**	**1.1582**	**1.9669**	**36.0738**	**0.0000**	**0.0000**
1760	**1.5990**	**1.1265**	**1.9559**	**35.1644**	**0.0000**	**0.0000**
1770	**1.6080**	**1.0910**	**1.9432**	**34.1560**	**0.0000**	**0.0000**
1783	**1.6195**	**1.0309**	**1.9198**	**32.4789**	**0.0000**	**0.0000**

Observe that about 150 km beneath the Surface of the Moon, that the pressure went below the program print limitations of about one millionth of an atmosphere. By projection we can safely say that the final indicatory surface pressure would have been less that 0.00001 Pascal or less than one ten millionth of an atmosphere. Any measured overflow to the surface would have been even less.

Allowing for a 10% tolerance in air pressure and density, our “Selenites”; I do not imagine that they would appreciate being referred to as “Lunatics”, or worse yet, “Moonies” or “Loonies”; would have a free unencumbered range of up to 140 km from the center of the Moon. Allowing for the interconnected cave system, they would have more habitable space than most Earth empires.

The following illustration depicts a graph of the acceleration due to gravity and the reduction in air density from the center. For an ideal gas at low pressures, the density is proportionate to the air pressure. The density has been indicated instead of the pressure because the numerical range is similar to the rate of acceleration due to gravity. The choice is a matter of convenience.



Observe that the rate of acceleration due to gravity for the “solid” Moon is a perfect linear slope.

Observe that the reducing air density appears to “flatten” out about 1,200 km from the center or about 500 km beneath the surface.

Here is an abridged return for the preceding program. It has mostly been cropped to multiples of 10. The inside of the Moon has been hollowed out to a vacancy of 300 km from the center. The inside is filled with a gas of a density of 1.2 kg per cubic meter at a pressure of 100 KPa.

```
Enter outer radius (c) (km)                 : 1783
Enter inner radius (a) a<c (km)             : 300
Enter surface gravity (gsu) (m/s^2)         : 1.62
Enter STP gas density (pst) (kg/m^3)        : 1.2
Enter interior air pressure (pin) (KPa)     : 100
Enter beginning value of [b] (b) a<=b<=c    : 300
Enter the ending value of [b](u) b<=u<=c    : 1783
```

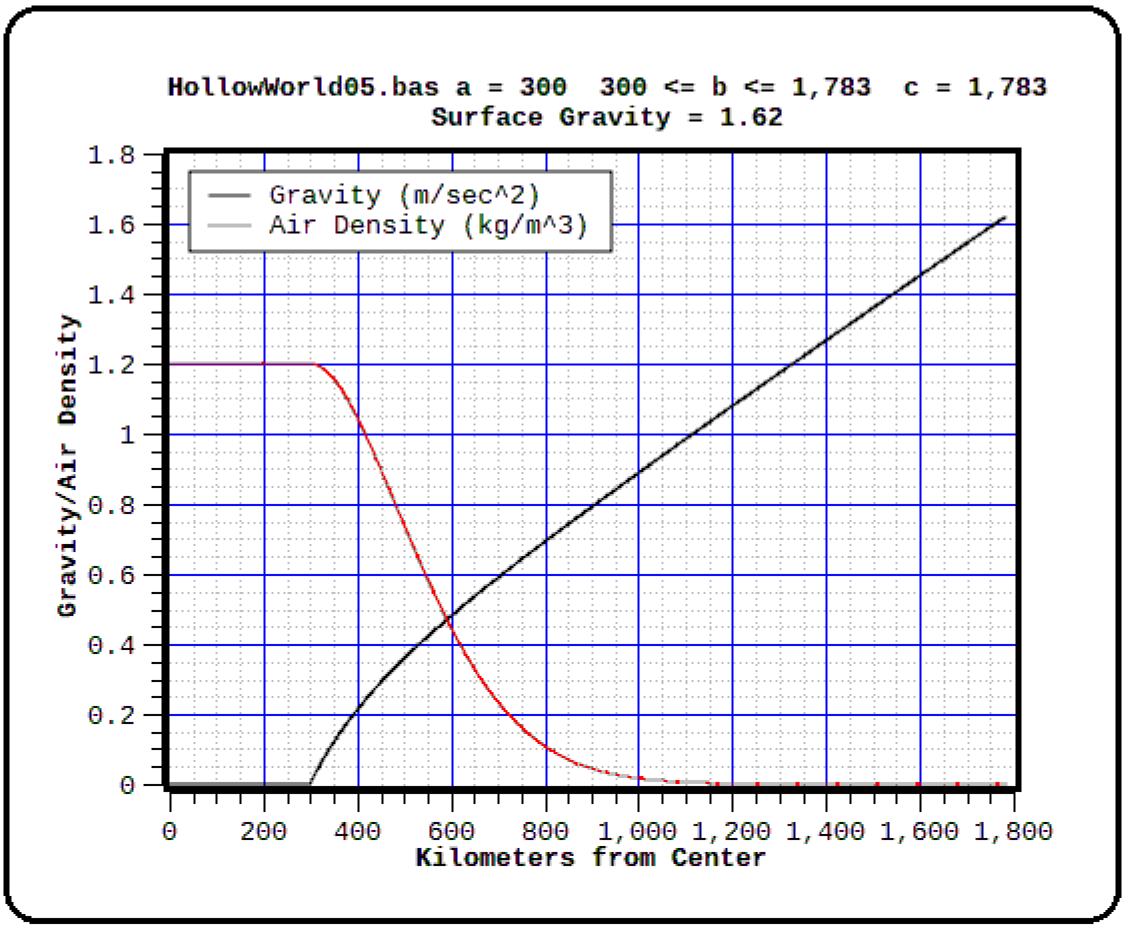
b	gx	gy	gn	q	Pressure	Density
0	0.0000				100.0000	1.2000
10	0.0000				100.0000	1.2000
20	0.0000				100.0000	1.2000
30	0.0000				100.0000	1.2000
40	0.0000				100.0000	1.2000
50	0.0000				100.0000	1.2000
60	0.0000				100.0000	1.2000
70	0.0000				100.0000	1.2000
80	0.0000				100.0000	1.2000
90	0.0000				100.0000	1.2000
100	0.0000				100.0000	1.2000
110	0.0000				100.0000	1.2000
120	0.0000				100.0000	1.2000
130	0.0000				100.0000	1.2000
140	0.0000				100.0000	1.2000
150	0.0000				100.0000	1.2000
160	0.0000				100.0000	1.2000
170	0.0000				100.0000	1.2000
180	0.0000				100.0000	1.2000
190	0.0000				100.0000	1.2000
200	0.0000				100.0000	1.2000
210	0.0000				100.0000	1.2000
220	0.0000				100.0000	1.2000
230	0.0000				100.0000	1.2000
240	0.0000				100.0000	1.2000
250	0.0000				100.0000	1.2000
260	0.0000				100.0000	1.2000
270	0.0000				100.0000	1.2000
280	0.0000				100.0000	1.2000
290	0.0000				100.0000	1.2000
300	0.0010	2.2437	2.2437	89.9741	100.0000	1.2000
310	0.0274	2.2727	2.2728	89.3102	99.8441	1.1981
320	0.0522	2.2905	2.2911	88.6945	99.3819	1.1926
330	0.0756	2.3036	2.3048	88.1195	98.6348	1.1836
340	0.0978	2.3137	2.3158	87.5787	97.6248	1.1715
350	0.1189	2.3217	2.3247	87.0677	96.3737	1.1565
360	0.1390	2.3281	2.3322	86.5824	94.9030	1.1388
370	0.1583	2.3331	2.3385	86.1194	93.2337	1.1188
380	0.1767	2.3372	2.3438	85.6762	91.3861	1.0966
390	0.1944	2.3404	2.3484	85.2506	89.3802	1.0726
400	0.2115	2.3428	2.3523	84.8405	87.2351	1.0468

410	0.2281	2.3446	2.3557	84.4442	84.9692	1.0196
420	0.2441	2.3459	2.3586	84.0605	82.6002	0.9912
430	0.2596	2.3468	2.3611	83.6877	80.1448	0.9617
440	0.2747	2.3472	2.3632	83.3249	77.6191	0.9314
450	0.2894	2.3473	2.3650	82.9715	75.0380	0.9005
460	0.3037	2.3470	2.3666	82.6259	72.4159	0.8690
470	0.3178	2.3464	2.3678	82.2880	69.7661	0.8372
480	0.3315	2.3456	2.3689	81.9565	67.1010	0.8052
490	0.3449	2.3445	2.3698	81.6314	64.4321	0.7732
500	0.3581	2.3432	2.3704	81.3117	61.7702	0.7412
510	0.3710	2.3418	2.3710	80.9971	59.1250	0.7095
520	0.3837	2.3401	2.3713	80.6870	56.5056	0.6781
530	0.3963	2.3382	2.3715	80.3812	53.9201	0.6470
540	0.4086	2.3362	2.3716	80.0791	51.3757	0.6165
550	0.4208	2.3340	2.3716	79.7806	48.8791	0.5865
560	0.4328	2.3317	2.3715	79.4853	46.4361	0.5572
570	0.4446	2.3292	2.3713	79.1928	44.0517	0.5286
580	0.4563	2.3266	2.3709	78.9030	41.7303	0.5008
590	0.4679	2.3239	2.3705	78.6155	39.4758	0.4737
600	0.4794	2.3210	2.3700	78.3302	37.2911	0.4475
610	0.4907	2.3180	2.3694	78.0470	35.1789	0.4221
620	0.5020	2.3149	2.3687	77.7654	33.1410	0.3977
630	0.5131	2.3117	2.3680	77.4857	31.1791	0.3741
640	0.5242	2.3084	2.3672	77.2073	29.2940	0.3515
650	0.5351	2.3050	2.3663	76.9302	27.4863	0.3298
660	0.5460	2.3015	2.3654	76.6545	25.7562	0.3091
670	0.5568	2.2979	2.3644	76.3794	24.1034	0.2892
680	0.5675	2.2942	2.3633	76.1056	22.5273	0.2703
690	0.5782	2.2904	2.3622	75.8325	21.0271	0.2523
700	0.5888	2.2865	2.3611	75.5601	19.6017	0.2352
710	0.5993	2.2825	2.3599	75.2885	18.2495	0.2190
720	0.6098	2.2784	2.3586	75.0172	16.9691	0.2036
730	0.6202	2.2742	2.3573	74.7463	15.7586	0.1891
740	0.6306	2.2700	2.3559	74.4758	14.6160	0.1754
750	0.6409	2.2656	2.3545	74.2057	13.5394	0.1625
760	0.6511	2.2612	2.3531	73.9355	12.5264	0.1503
770	0.6614	2.2566	2.3516	73.6656	11.5749	0.1389
780	0.6716	2.2520	2.3500	73.3955	10.6825	0.1282
790	0.6817	2.2473	2.3484	73.1254	9.8467	0.1182
800	0.6918	2.2425	2.3468	72.8553	9.0653	0.1088
810	0.7019	2.2376	2.3451	72.5851	8.3356	0.1000
820	0.7119	2.2327	2.3434	72.3146	7.6554	0.0919
830	0.7219	2.2276	2.3417	72.0438	7.0221	0.0843
840	0.7319	2.2225	2.3399	71.7725	6.4335	0.0772
850	0.7418	2.2172	2.3380	71.5009	5.8871	0.0706
860	0.7517	2.2119	2.3362	71.2291	5.3806	0.0646
870	0.7616	2.2065	2.3343	70.9564	4.9118	0.0589
880	0.7715	2.2010	2.3323	70.6836	4.4785	0.0537
890	0.7813	2.1954	2.3303	70.4097	4.0785	0.0489
900	0.7911	2.1898	2.3283	70.1357	3.7099	0.0445
910	0.8009	2.1840	2.3262	69.8604	3.3706	0.0404
920	0.8107	2.1781	2.3241	69.5844	3.0586	0.0367
930	0.8205	2.1722	2.3220	69.3080	2.7723	0.0333
940	0.8302	2.1662	2.3198	69.0303	2.5098	0.0301
950	0.8399	2.1601	2.3176	68.7521	2.2695	0.0272

960	0.8496	2.1538	2.3153	68.4728	2.0498	0.0246
970	0.8593	2.1475	2.3131	68.1926	1.8491	0.0222
980	0.8689	2.1411	2.3107	67.9113	1.6662	0.0200
990	0.8786	2.1346	2.3084	67.6291	1.4996	0.0180
1000	0.8882	2.1280	2.3060	67.3454	1.3481	0.0162
1010	0.8978	2.1214	2.3035	67.0607	1.2105	0.0145
1020	0.9074	2.1146	2.3011	66.7749	1.0856	0.0130
1030	0.9170	2.1077	2.2986	66.4878	0.9725	0.0117
1040	0.9266	2.1007	2.2960	66.1995	0.8702	0.0104
1050	0.9361	2.0937	2.2934	65.9097	0.7777	0.0093
1060	0.9457	2.0865	2.2908	65.6184	0.6943	0.0083
1070	0.9552	2.0792	2.2881	65.3255	0.6191	0.0074
1080	0.9647	2.0718	2.2854	65.0315	0.5514	0.0066
1090	0.9743	2.0644	2.2827	64.7356	0.4905	0.0059
1100	0.9838	2.0568	2.2799	64.4384	0.4359	0.0052
1110	0.9933	2.0491	2.2771	64.1391	0.3869	0.0046
1120	1.0027	2.0413	2.2743	63.8387	0.3430	0.0041
1130	1.0122	2.0334	2.2714	63.5362	0.3037	0.0036
1140	1.0217	2.0254	2.2685	63.2317	0.2687	0.0032
1150	1.0311	2.0172	2.2655	62.9260	0.2374	0.0028
1160	1.0406	2.0090	2.2625	62.6177	0.2095	0.0025
1170	1.0500	2.0006	2.2594	62.3075	0.1846	0.0022
1180	1.0595	1.9922	2.2564	61.9957	0.1626	0.0020
1190	1.0689	1.9836	2.2532	61.6814	0.1430	0.0017
1200	1.0783	1.9749	2.2501	61.3652	0.1256	0.0015
1210	1.0877	1.9660	2.2469	61.0464	0.1102	0.0013
1220	1.0971	1.9571	2.2436	60.7257	0.0966	0.0012
1230	1.1065	1.9480	2.2403	60.4025	0.0845	0.0010
1240	1.1159	1.9388	2.2370	60.0768	0.0739	0.0009
1250	1.1253	1.9294	2.2336	59.7484	0.0646	0.0008
1260	1.1346	1.9199	2.2302	59.4178	0.0563	0.0007
1270	1.1440	1.9103	2.2267	59.0843	0.0491	0.0006
1280	1.1534	1.9006	2.2232	58.7481	0.0427	0.0005
1290	1.1627	1.8907	2.2196	58.4091	0.0372	0.0004
1300	1.1721	1.8807	2.2160	58.0671	0.0323	0.0004
1310	1.1815	1.8705	2.2124	57.7224	0.0280	0.0003
1320	1.1908	1.8602	2.2087	57.3742	0.0243	0.0003
1330	1.2001	1.8497	2.2049	57.0228	0.0210	0.0003
1340	1.2095	1.8390	2.2011	56.6683	0.0181	0.0002
1350	1.2188	1.8282	2.1973	56.3103	0.0157	0.0002
1360	1.2281	1.8173	2.1933	55.9487	0.0135	0.0002
1370	1.2375	1.8061	2.1894	55.5835	0.0116	0.0001
1380	1.2468	1.7948	2.1854	55.2146	0.0100	0.0001
1390	1.2561	1.7834	2.1813	54.8417	0.0086	0.0001
1400	1.2654	1.7717	2.1772	54.4648	0.0074	0.0001
1410	1.2747	1.7599	2.1730	54.0838	0.0063	0.0001
1420	1.2840	1.7479	2.1688	53.6987	0.0054	0.0001
1430	1.2933	1.7356	2.1645	53.3076	0.0047	0.0001
1440	1.3026	1.7232	2.1601	52.9142	0.0040	0.0000
1450	1.3119	1.7106	2.1557	52.5148	0.0034	0.0000
1460	1.3212	1.6977	2.1512	52.1100	0.0029	0.0000
1470	1.3305	1.6847	2.1467	51.6998	0.0025	0.0000
1480	1.3397	1.6714	2.1420	51.2847	0.0021	0.0000
1490	1.3490	1.6578	2.1373	50.8634	0.0018	0.0000
1500	1.3583	1.6440	2.1326	50.4366	0.0015	0.0000

1510	**1.3676**	**1.6300**	**2.1277**	**50.0031**	**0.0013**	**0.0000**
1520	**1.3769**	**1.6157**	**2.1228**	**49.5638**	**0.0011**	**0.0000**
1530	**1.3861**	**1.6011**	**2.1178**	**49.1170**	**0.0009**	**0.0000**
1540	**1.3954**	**1.5863**	**2.1127**	**48.6635**	**0.0008**	**0.0000**
1549	**1.4037**	**1.5727**	**2.1080**	**48.2494**	**0.0007**	**0.0000**
1560	**1.4139**	**1.5557**	**2.1022**	**47.7337**	**0.0005**	**0.0000**
1570	**1.4232**	**1.5399**	**2.0968**	**47.2562**	**0.0005**	**0.0000**
1580	**1.4324**	**1.5238**	**2.0913**	**46.7704**	**0.0004**	**0.0000**
1590	**1.4417**	**1.5073**	**2.0857**	**46.2747**	**0.0003**	**0.0000**
1600	**1.4509**	**1.4904**	**2.0800**	**45.7696**	**0.0003**	**0.0000**
1610	**1.4602**	**1.4731**	**2.0742**	**45.2534**	**0.0002**	**0.0000**
1620	**1.4694**	**1.4554**	**2.0682**	**44.7257**	**0.0002**	**0.0000**
1630	**1.4787**	**1.4373**	**2.0621**	**44.1870**	**0.0002**	**0.0000**
1640	**1.4879**	**1.4186**	**2.0558**	**43.6347**	**0.0001**	**0.0000**
1650	**1.4971**	**1.3995**	**2.0494**	**43.0686**	**0.0001**	**0.0000**
1660	**1.5064**	**1.3797**	**2.0427**	**42.4874**	**0.0001**	**0.0000**
1670	**1.5156**	**1.3593**	**2.0359**	**41.8889**	**0.0001**	**0.0000**
1680	**1.5249**	**1.3383**	**2.0289**	**41.2723**	**0.0001**	**0.0000**
1690	**1.5341**	**1.3165**	**2.0215**	**40.6357**	**0.0001**	**0.0000**
1700	**1.5433**	**1.2939**	**2.0140**	**39.9765**	**0.0000**	**0.0000**
1710	**1.5525**	**1.2704**	**2.0060**	**39.2929**	**0.0000**	**0.0000**
1720	**1.5618**	**1.2457**	**1.9977**	**38.5770**	**0.0000**	**0.0000**
1730	**1.5710**	**1.2199**	**1.9890**	**37.8292**	**0.0000**	**0.0000**
1740	**1.5802**	**1.1924**	**1.9796**	**37.0378**	**0.0000**	**0.0000**
1749	**1.5885**	**1.1662**	**1.9706**	**36.2857**	**0.0000**	**0.0000**
1760	**1.5987**	**1.1313**	**1.9585**	**35.2858**	**0.0000**	**0.0000**
1770	**1.6079**	**1.0957**	**1.9457**	**34.2733**	**0.0000**	**0.0000**
1780	**1.6170**	**1.0529**	**1.9296**	**33.0689**	**0.0000**	**0.0000**
1781	**1.6181**	**1.0476**	**1.9276**	**32.9200**	**0.0000**	**0.0000**
1782	**1.6188**	**1.0419**	**1.9251**	**32.7670**	**0.0000**	**0.0000**
1783	**1.6195**	**1.0353**	**1.9222**	**32.5902**	**0.0000**	**0.0000**

Here is the graph of the preceding run depicting the acceleration due to gravity and the air density, both with respect to the distance from the center of the Moon. The STP density of the initial charge of air in the hollow core was entered as 1.2 kg per cubic meter. The Standard pressure was fudged as 100 KPa. The reality is slightly greater, but this is a round number suitable for developing indications. The initial air pressure was entered as 100 Kpa. The density of the air was graphed instead of the pressure because the initial numeric value would have overwhelmed the gravity trace,



This next return is for a hollow space inside of the Moon with a diameter of 1,200 km. That is a surface area of 4,523,890 square kilometers, or about the area of the contiguous United States. The volume of this hollow zone is 904,777,920 cubic kilometers, representing a mere 3.81% of the total volume of the Moon. This space is wholly filled with gases at a reasonable pressure. There would also be complex network of caves adjoining the hollow space in the center.

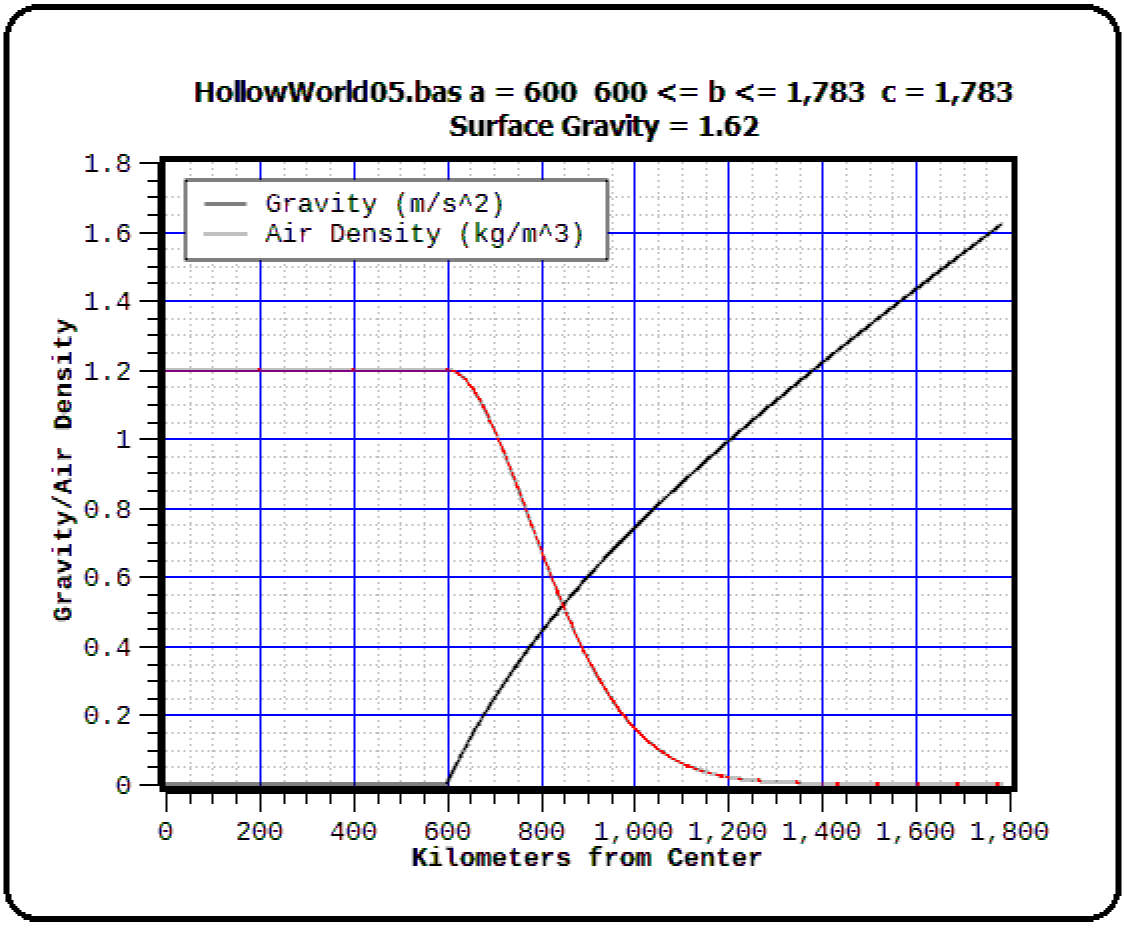
```
Enter outer radius (c) (km)                 : 1783
Enter inner radius (a) a<c (km)             : 600
Enter surface gravity (gsu) (m/s^2)         : 1.62
Enter STP gas density (pst) (kg/m^3)        : 1.2
Enter interior air pressure (pin) (KPa)     : 100
Enter beginning value of [b] (b) a<=b<=c    : 600
Enter the ending value of [b](u) b<=u<=c    : 1783
```

b	gx	gy	gn	q	Pressure	Density
0	0.0000				100.0000	1.2000
10	0.0000				100.0000	1.2000
20	0.0000				100.0000	1.2000
30	0.0000				100.0000	1.2000
40	0.0000				100.0000	1.2000
50	0.0000				100.0000	1.2000
60	0.0000				100.0000	1.2000
70	0.0000				100.0000	1.2000
80	0.0000				100.0000	1.2000
90	0.0000				100.0000	1.2000
100	0.0000				100.0000	1.2000
110	0.0000				100.0000	1.2000
120	0.0000				100.0000	1.2000
130	0.0000				100.0000	1.2000
140	0.0000				100.0000	1.2000
150	0.0000				100.0000	1.2000
160	0.0000				100.0000	1.2000
170	0.0000				100.0000	1.2000
180	0.0000				100.0000	1.2000
190	0.0000				100.0000	1.2000
200	0.0000				100.0000	1.2000
210	0.0000				100.0000	1.2000
220	0.0000				100.0000	1.2000
230	0.0000				100.0000	1.2000
240	0.0000				100.0000	1.2000
250	0.0000				100.0000	1.2000
260	0.0000				100.0000	1.2000
270	0.0000				100.0000	1.2000
280	0.0000				100.0000	1.2000
290	0.0000				100.0000	1.2000
300	0.0000				100.0000	1.2000
310	0.0000				100.0000	1.2000
320	0.0000				100.0000	1.2000
330	0.0000				100.0000	1.2000
340	0.0000				100.0000	1.2000
350	0.0000				100.0000	1.2000
360	0.0000				100.0000	1.2000
370	0.0000				100.0000	1.2000

380	**0.0000**				**100.0000**	**1.2000**
390	**0.0000**				**100.0000**	**1.2000**
400	**0.0000**				**100.0000**	**1.2000**
410	**0.0000**				**100.0000**	**1.2000**
420	**0.0000**				**100.0000**	**1.2000**
430	**0.0000**				**100.0000**	**1.2000**
440	**0.0000**				**100.0000**	**1.2000**
450	**0.0000**				**100.0000**	**1.2000**
460	**0.0000**				**100.0000**	**1.2000**
470	**0.0000**				**100.0000**	**1.2000**
480	**0.0000**				**100.0000**	**1.2000**
490	**0.0000**				**100.0000**	**1.2000**
500	**0.0000**				**100.0000**	**1.2000**
510	**0.0000**				**100.0000**	**1.2000**
520	**0.0000**				**100.0000**	**1.2000**
530	**0.0000**				**100.0000**	**1.2000**
540	**0.0000**				**100.0000**	**1.2000**
550	**0.0000**				**100.0000**	**1.2000**
560	**0.0000**				**100.0000**	**1.2000**
570	**0.0000**				**100.0000**	**1.2000**
580	**0.0000**				**100.0000**	**1.2000**
590	**0.0000**				**100.0000**	**1.2000**
600	**0.0011**	**2.0584**	**2.0584**	**89.9706**	**100.0000**	**1.2000**
610	**0.0288**	**2.0929**	**2.0931**	**89.2119**	**99.8370**	**1.1980**
620	**0.0557**	**2.1160**	**2.1168**	**88.4911**	**99.3470**	**1.1922**
630	**0.0819**	**2.1342**	**2.1357**	**87.8034**	**98.5445**	**1.1825**
640	**0.1072**	**2.1491**	**2.1517**	**87.1439**	**97.4464**	**1.1694**
650	**0.1318**	**2.1615**	**2.1655**	**86.5096**	**96.0712**	**1.1529**
660	**0.1558**	**2.1721**	**2.1777**	**85.8981**	**94.4391**	**1.1333**
670	**0.1791**	**2.1811**	**2.1884**	**85.3064**	**92.5711**	**1.1109**
680	**0.2018**	**2.1887**	**2.1980**	**84.7333**	**90.4893**	**1.0859**
690	**0.2239**	**2.1952**	**2.2066**	**84.1769**	**88.2160**	**1.0586**
700	**0.2455**	**2.2007**	**2.2144**	**83.6359**	**85.7738**	**1.0293**
710	**0.2665**	**2.2054**	**2.2214**	**83.1090**	**83.1852**	**0.9982**
720	**0.2871**	**2.2092**	**2.2278**	**82.5952**	**80.4724**	**0.9657**
730	**0.3072**	**2.2123**	**2.2336**	**82.0935**	**77.6574**	**0.9319**
740	**0.3270**	**2.2148**	**2.2388**	**81.6027**	**74.7610**	**0.8971**
750	**0.3462**	**2.2167**	**2.2436**	**81.1225**	**71.8037**	**0.8616**
760	**0.3652**	**2.2181**	**2.2479**	**80.6515**	**68.8046**	**0.8257**
770	**0.3837**	**2.2190**	**2.2519**	**80.1897**	**65.7820**	**0.7894**
780	**0.4019**	**2.2194**	**2.2555**	**79.7360**	**62.7529**	**0.7530**
790	**0.4198**	**2.2194**	**2.2587**	**79.2901**	**59.7333**	**0.7168**
800	**0.4373**	**2.2190**	**2.2617**	**78.8513**	**56.7375**	**0.6808**
810	**0.4546**	**2.2183**	**2.2643**	**78.4194**	**53.7788**	**0.6453**
820	**0.4715**	**2.2171**	**2.2667**	**77.9935**	**50.8692**	**0.6104**
830	**0.4882**	**2.2157**	**2.2689**	**77.5735**	**48.0193**	**0.5762**
840	**0.5047**	**2.2140**	**2.2708**	**77.1591**	**45.2385**	**0.5429**
850	**0.5209**	**2.2120**	**2.2725**	**76.7499**	**42.5347**	**0.5104**
860	**0.5368**	**2.2097**	**2.2739**	**76.3449**	**39.9149**	**0.4790**
870	**0.5526**	**2.2071**	**2.2752**	**75.9443**	**37.3848**	**0.4486**
880	**0.5681**	**2.2043**	**2.2763**	**75.5480**	**34.9490**	**0.4194**
890	**0.5834**	**2.2012**	**2.2772**	**75.1557**	**32.6110**	**0.3913**
900	**0.5985**	**2.1979**	**2.2780**	**74.7667**	**30.3734**	**0.3645**
910	**0.6135**	**2.1944**	**2.2786**	**74.3810**	**28.2380**	**0.3389**
920	**0.6282**	**2.1907**	**2.2790**	**73.9984**	**26.2056**	**0.3145**

930	0.6428	2.1868	2.2793	73.6185	24.2763	0.2913
940	0.6573	2.1826	2.2795	73.2412	22.4497	0.2694
950	0.6715	2.1783	2.2795	72.8664	20.7244	0.2487
960	0.6857	2.1738	2.2794	72.4939	19.0989	0.2292
970	0.6996	2.1691	2.2792	72.1233	17.5710	0.2109
980	0.7135	2.1642	2.2788	71.7542	16.1381	0.1937
990	0.7272	2.1592	2.2783	71.3871	14.7974	0.1776
1000	0.7408	2.1540	2.2778	71.0215	13.5456	0.1625
1010	0.7542	2.1486	2.2771	70.6571	12.3795	0.1486
1020	0.7676	2.1430	2.2763	70.2941	11.2954	0.1355
1030	0.7808	2.1373	2.2755	69.9321	10.2896	0.1235
1040	0.7939	2.1314	2.2745	69.5705	9.3585	0.1123
1050	0.8069	2.1254	2.2734	69.2103	8.4981	0.1020
1060	0.8198	2.1192	2.2722	68.8503	7.7047	0.0925
1070	0.8327	2.1128	2.2710	68.4910	6.9746	0.0837
1080	0.8454	2.1063	2.2696	68.1320	6.3038	0.0756
1090	0.8580	2.0997	2.2682	67.7733	5.6888	0.0683
1100	0.8706	2.0929	2.2667	67.4143	5.1260	0.0615
1110	0.8830	2.0859	2.2651	67.0560	4.6118	0.0553
1120	0.8954	2.0788	2.2635	66.6972	4.1430	0.0497
1130	0.9077	2.0716	2.2617	66.3379	3.7162	0.0446
1140	0.9199	2.0642	2.2599	65.9787	3.3285	0.0399
1150	0.9321	2.0566	2.2580	65.6186	2.9768	0.0357
1160	0.9442	2.0489	2.2560	65.2585	2.6583	0.0319
1170	0.9562	2.0411	2.2540	64.8974	2.3705	0.0284
1180	0.9682	2.0331	2.2518	64.5358	2.1107	0.0253
1190	0.9801	2.0249	2.2496	64.1731	1.8767	0.0225
1200	0.9919	2.0166	2.2474	63.8093	1.6662	0.0200
1210	1.0037	2.0082	2.2450	63.4442	1.4772	0.0177
1220	1.0154	1.9996	2.2426	63.0781	1.3078	0.0157
1230	1.0271	1.9908	2.2401	62.7111	1.1562	0.0139
1240	1.0387	1.9819	2.2376	62.3423	1.0207	0.0122
1250	1.0502	1.9728	2.2350	61.9720	0.8998	0.0108
1260	1.0617	1.9636	2.2323	61.6001	0.7921	0.0095
1270	1.0732	1.9542	2.2295	61.2265	0.6964	0.0084
1280	1.0846	1.9447	2.2267	60.8505	0.6113	0.0073
1290	1.0960	1.9350	2.2238	60.4732	0.5359	0.0064
1300	1.1073	1.9251	2.2208	60.0933	0.4692	0.0056
1310	1.1185	1.9151	2.2178	59.7116	0.4102	0.0049
1320	1.1298	1.9048	2.2147	59.3272	0.3581	0.0043
1330	1.1410	1.8945	2.2115	58.9403	0.3122	0.0037
1340	1.1521	1.8839	2.2083	58.5514	0.2719	0.0033
1350	1.1633	1.8732	2.2050	58.1591	0.2364	0.0028
1360	1.1743	1.8622	2.2016	57.7641	0.2053	0.0025
1370	1.1854	1.8511	2.1982	57.3662	0.1780	0.0021
1380	1.1964	1.8398	2.1946	56.9649	0.1541	0.0018
1390	1.2074	1.8284	2.1910	56.5605	0.1333	0.0016
1400	1.2183	1.8167	2.1874	56.1526	0.1151	0.0014
1410	1.2292	1.8048	2.1836	55.7411	0.0993	0.0012
1420	1.2401	1.7927	2.1798	55.3263	0.0855	0.0010
1430	1.2510	1.7803	2.1759	54.9055	0.0736	0.0009
1440	1.2618	1.7679	2.1720	54.4830	0.0632	0.0008
1450	1.2726	1.7551	2.1679	54.0550	0.0542	0.0007
1460	1.2834	1.7421	2.1638	53.6221	0.0465	0.0006
1470	1.2941	1.7289	2.1596	53.1843	0.0398	0.0005

1480	**1.3048**	**1.7154**	**2.1553**	**52.7421**	**0.0340**	**0.0004**
1490	**1.3155**	**1.7017**	**2.1509**	**52.2940**	**0.0290**	**0.0003**
1500	**1.3262**	**1.6877**	**2.1464**	**51.8408**	**0.0247**	**0.0003**
1510	**1.3368**	**1.6735**	**2.1419**	**51.3813**	**0.0210**	**0.0003**
1520	**1.3474**	**1.6590**	**2.1372**	**50.9159**	**0.0179**	**0.0002**
1530	**1.3580**	**1.6442**	**2.1325**	**50.4439**	**0.0152**	**0.0002**
1540	**1.3686**	**1.6290**	**2.1276**	**49.9651**	**0.0129**	**0.0002**
1550	**1.3792**	**1.6136**	**2.1227**	**49.4790**	**0.0109**	**0.0001**
1560	**1.3897**	**1.5979**	**2.1176**	**48.9860**	**0.0092**	**0.0001**
1570	**1.4002**	**1.5817**	**2.1125**	**48.4839**	**0.0078**	**0.0001**
1580	**1.4107**	**1.5653**	**2.1072**	**47.9740**	**0.0066**	**0.0001**
1590	**1.4211**	**1.5484**	**2.1017**	**47.4542**	**0.0055**	**0.0001**
1600	**1.4316**	**1.5312**	**2.0962**	**46.9255**	**0.0047**	**0.0001**
1610	**1.4420**	**1.5135**	**2.0905**	**46.3857**	**0.0039**	**0.0000**
1620	**1.4524**	**1.4954**	**2.0846**	**45.8345**	**0.0033**	**0.0000**
1630	**1.4628**	**1.4768**	**2.0787**	**45.2726**	**0.0028**	**0.0000**
1640	**1.4732**	**1.4577**	**2.0725**	**44.6969**	**0.0023**	**0.0000**
1650	**1.4836**	**1.4380**	**2.0661**	**44.1075**	**0.0019**	**0.0000**
1660	**1.4939**	**1.4178**	**2.0596**	**43.5032**	**0.0016**	**0.0000**
1670	**1.5042**	**1.3969**	**2.0528**	**42.8814**	**0.0013**	**0.0000**
1680	**1.5146**	**1.3753**	**2.0458**	**42.2415**	**0.0011**	**0.0000**
1690	**1.5249**	**1.3530**	**2.0385**	**41.5817**	**0.0009**	**0.0000**
1700	**1.5351**	**1.3297**	**2.0310**	**40.8989**	**0.0008**	**0.0000**
1710	**1.5454**	**1.3056**	**2.0230**	**40.1916**	**0.0006**	**0.0000**
1720	**1.5557**	**1.2802**	**2.0147**	**39.4515**	**0.0005**	**0.0000**
1730	**1.5659**	**1.2536**	**2.0059**	**38.6793**	**0.0004**	**0.0000**
1740	**1.5761**	**1.2253**	**1.9964**	**37.8627**	**0.0004**	**0.0000**
1750	**1.5863**	**1.1953**	**1.9862**	**36.9979**	**0.0003**	**0.0000**
1760	**1.5966**	**1.1624**	**1.9749**	**36.0576**	**0.0002**	**0.0000**
1770	**1.6067**	**1.1257**	**1.9618**	**35.0163**	**0.0002**	**0.0000**
1780	**1.6168**	**1.0815**	**1.9452**	**33.7791**	**0.0002**	**0.0000**
1781	**1.6180**	**1.0760**	**1.9431**	**33.6264**	**0.0002**	**0.0000**
1782	**1.6188**	**1.0702**	**1.9406**	**33.4696**	**0.0002**	**0.0000**
1783	**1.6196**	**1.0634**	**1.9375**	**33.2886**	**0.0002**	**0.0000**


HollowWorld05.bas a = 600 600 <= b <= 1,783 c = 1,783
Surface Gravity = 1.62
Gravity (m/s^2)
Air Density (kg/m^3)
Gravity/Air Density
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
Kilometers from Center

Here is a run where approximately half of the diameter of the Moon is a hollow vacancy. The inner radius is 900 km and the shell has a thickness of 873 km. The inner vacancy occupies a space of 0.1286 of the total volume. This is still presumably a less percentage that the relative volume of the interconnected caverns within the shell.

```
Enter outer radius (c) (km)                 : 1783
Enter inner radius (a) a<c (km)             : 900
Enter surface gravity (gsu) (m/s^2)         : 1.62
Enter STP gas density (pst) (kg/m^3)        : 1.2
Enter interior air pressure (pin) (KPa)     : 100
Enter beginning value of [b] (b) a<=b<=c    : 900
Enter the ending value of [b](u) b<=u<=c    : 1200
  b    gx       gy       gn       q      Pressure   Density
   0   0.0000                            100.0000   1.2000
  10   0.0000                            100.0000   1.2000
  20   0.0000                            100.0000   1.2000
  30   0.0000                            100.0000   1.2000
  40   0.0000                            100.0000   1.2000
  50   0.0000                            100.0000   1.2000
  60   0.0000                            100.0000   1.2000
  70   0.0000                            100.0000   1.2000
  80   0.0000                            100.0000   1.2000
  90   0.0000                            100.0000   1.2000
 100   0.0000                            100.0000   1.2000
 110   0.0000                            100.0000   1.2000
 120   0.0000                            100.0000   1.2000
 130   0.0000                            100.0000   1.2000
 140   0.0000                            100.0000   1.2000
 150   0.0000                            100.0000   1.2000
 160   0.0000                            100.0000   1.2000
 170   0.0000                            100.0000   1.2000
 180   0.0000                            100.0000   1.2000
 190   0.0000                            100.0000   1.2000
 200   0.0000                            100.0000   1.2000
 210   0.0000                            100.0000   1.2000
 220   0.0000                            100.0000   1.2000
 230   0.0000                            100.0000   1.2000
 240   0.0000                            100.0000   1.2000
 250   0.0000                            100.0000   1.2000
 260   0.0000                            100.0000   1.2000
 270   0.0000                            100.0000   1.2000
 280   0.0000                            100.0000   1.2000
 290   0.0000                            100.0000   1.2000
 300   0.0000                            100.0000   1.2000
 310   0.0000                            100.0000   1.2000
 320   0.0000                            100.0000   1.2000
 330   0.0000                            100.0000   1.2000
 340   0.0000                            100.0000   1.2000
 350   0.0000                            100.0000   1.2000
 360   0.0000                            100.0000   1.2000
 370   0.0000                            100.0000   1.2000
 380   0.0000                            100.0000   1.2000
```

390	0.0000				100.0000	1.2000
400	0.0000				100.0000	1.2000
410	0.0000				100.0000	1.2000
420	0.0000				100.0000	1.2000
430	0.0000				100.0000	1.2000
440	0.0000				100.0000	1.2000
450	0.0000				100.0000	1.2000
460	0.0000				100.0000	1.2000
470	0.0000				100.0000	1.2000
480	0.0000				100.0000	1.2000
490	0.0000				100.0000	1.2000
500	0.0000				100.0000	1.2000
510	0.0000				100.0000	1.2000
520	0.0000				100.0000	1.2000
530	0.0000				100.0000	1.2000
540	0.0000				100.0000	1.2000
550	0.0000				100.0000	1.2000
560	0.0000				100.0000	1.2000
570	0.0000				100.0000	1.2000
580	0.0000				100.0000	1.2000
590	0.0000				100.0000	1.2000
600	0.0000				100.0000	1.2000
610	0.0000				100.0000	1.2000
620	0.0000				100.0000	1.2000
630	0.0000				100.0000	1.2000
640	0.0000				100.0000	1.2000
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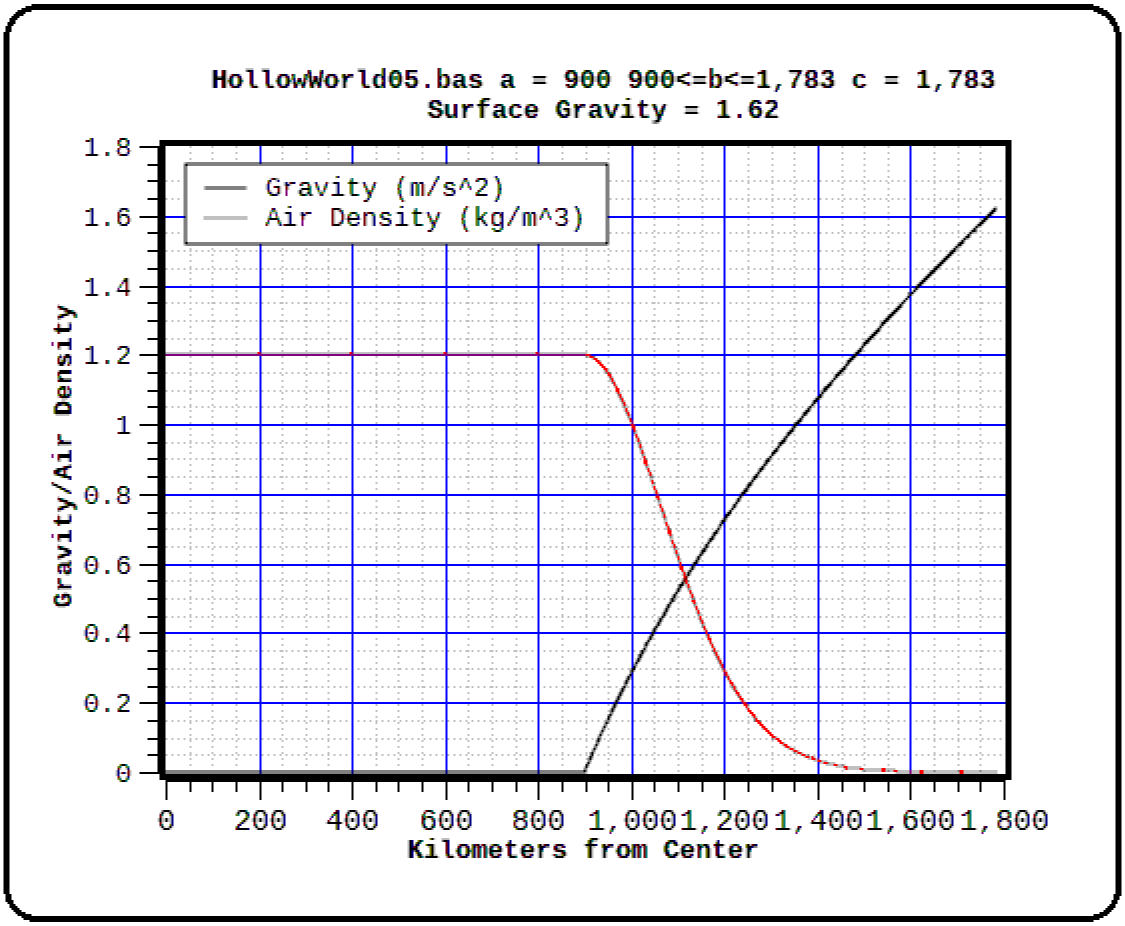
660	0.0000				100.0000	1.2000
670	0.0000				100.0000	1.2000
680	0.0000				100.0000	1.2000
690	0.0000				100.0000	1.2000
700	0.0000				100.0000	1.2000
710	0.0000				100.0000	1.2000
720	0.0000				100.0000	1.2000
730	0.0000				100.0000	1.2000
740	0.0000				100.0000	1.2000
750	0.0000				100.0000	1.2000
760	0.0000				100.0000	1.2000
770	0.0000				100.0000	1.2000
780	0.0000				100.0000	1.2000
790	0.0000				100.0000	1.2000
800	0.0000				100.0000	1.2000
810	0.0000				100.0000	1.2000
820	0.0000				100.0000	1.2000
830	0.0000				100.0000	1.2000
840	0.0000				100.0000	1.2000
850	0.0000				100.0000	1.2000
860	0.0000				100.0000	1.2000
870	0.0000				100.0000	1.2000
880	0.0000				100.0000	1.2000
890	0.0000				100.0000	1.2000
900	0.0012	1.9122	1.9122	89.9652	100.0000	1.2000
910	0.0320	1.9519	1.9522	89.0620	99.8194	1.1978
920	0.0622	1.9791	1.9801	88.2000	99.2743	1.1913
930	0.0918	2.0008	2.0029	87.3730	98.3777	1.1805

940	0.1208	2.0189	2.0225	86.5759	97.1463	1.1658
950	0.1492	2.0343	2.0398	85.8047	95.5996	1.1472
960	0.1771	2.0475	2.0551	85.0570	93.7595	1.1251
970	0.2044	2.0589	2.0690	84.3302	91.6500	1.0998
980	0.2312	2.0686	2.0815	83.6225	89.2965	1.0716
990	0.2575	2.0771	2.0930	82.9325	86.7256	1.0407
1000	0.2834	2.0843	2.1035	82.2583	83.9645	1.0076
1010	0.3087	2.0904	2.1131	81.5986	81.0408	0.9725
1020	0.3337	2.0956	2.1220	80.9527	77.9820	0.9358
1030	0.3582	2.0999	2.1302	80.3194	74.8151	0.8978
1040	0.3823	2.1033	2.1377	79.6971	71.5666	0.8588
1050	0.4061	2.1059	2.1447	79.0861	68.2619	0.8191
1060	0.4294	2.1079	2.1512	78.4851	64.9250	0.7791
1070	0.4524	2.1092	2.1572	77.8936	61.5787	0.7389
1080	0.4751	2.1099	2.1627	77.3107	58.2442	0.6989
1090	0.4974	2.1100	2.1678	76.7361	54.9408	0.6593
1100	0.5194	2.1095	2.1725	76.1686	51.6864	0.6202
1110	0.5411	2.1086	2.1769	75.6085	48.4966	0.5820
1120	0.5624	2.1071	2.1809	75.0551	45.3854	0.5446
1130	0.5835	2.1052	2.1846	74.5072	42.3649	0.5084
1140	0.6043	2.1028	2.1879	73.9655	39.4453	0.4733
1150	0.6249	2.1000	2.1910	73.4291	36.6352	0.4396
1160	0.6452	2.0967	2.1938	72.8971	33.9414	0.4073
1170	0.6652	2.0932	2.1963	72.3703	31.3691	0.3764
1180	0.6850	2.0891	2.1985	71.8466	28.9219	0.3471
1190	0.7045	2.0847	2.2006	71.3275	26.6023	0.3192
1200	0.7239	2.0800	2.2023	70.8118	24.4111	0.2929
1210	0.7429	2.0749	2.2039	70.2995	22.3484	0.2682
1220	0.7619	2.0694	2.2052	69.7891	20.4129	0.2450
1230	0.7805	2.0637	2.2064	69.2821	18.6027	0.2232
1240	0.7990	2.0576	2.2073	68.7771	16.9148	0.2030
1250	0.8173	2.0512	2.2080	68.2746	15.3459	0.1842
1260	0.8354	2.0444	2.2085	67.7739	13.8917	0.1667
1270	0.8533	2.0374	2.2089	67.2741	12.5480	0.1506
1280	0.8711	2.0301	2.2091	66.7757	11.3097	0.1357
1290	0.8887	2.0224	2.2091	66.2787	10.1718	0.1221
1300	0.9061	2.0145	2.2089	65.7818	9.1289	0.1095
1310	0.9234	2.0063	2.2085	65.2861	8.1758	0.0981
1320	0.9405	1.9977	2.2080	64.7909	7.3069	0.0877
1330	0.9574	1.9889	2.2074	64.2949	6.5169	0.0782
1340	0.9742	1.9798	2.2065	63.7991	5.8004	0.0696
1350	0.9909	1.9704	2.2056	63.3031	5.1521	0.0618
1360	1.0074	1.9608	2.2044	62.8065	4.5671	0.0548
1370	1.0238	1.9508	2.2032	62.3090	4.0405	0.0485
1380	1.0401	1.9406	2.2017	61.8103	3.5675	0.0428
1390	1.0562	1.9301	2.2002	61.3101	3.1436	0.0377
1400	1.0723	1.9193	2.1985	60.8089	2.7647	0.0332
1410	1.0881	1.9081	2.1966	60.3054	2.4268	0.0291
1420	1.1039	1.8967	2.1946	59.8003	2.1260	0.0255
1430	1.1196	1.8850	2.1925	59.2917	1.8590	0.0223
1440	1.1352	1.8731	2.1902	58.7824	1.6224	0.0195
1450	1.1506	1.8608	2.1878	58.2699	1.4133	0.0170
1460	1.1660	1.8482	2.1852	57.7530	1.2288	0.0147
1470	1.1812	1.8352	2.1825	57.2326	1.0664	0.0128
1480	1.1964	1.8220	2.1797	56.7089	0.9238	0.0111

1490	1.2115	1.8084	2.1767	56.1816	0.7987	0.0096
1500	1.2264	1.7945	2.1735	55.6496	0.6894	0.0083
1510	1.2413	1.7802	2.1703	55.1126	0.5939	0.0071
1520	1.2561	1.7656	2.1669	54.5712	0.5107	0.0061
1530	1.2708	1.7507	2.1633	54.0235	0.4384	0.0053
1540	1.2854	1.7353	2.1596	53.4708	0.3757	0.0045
1550	1.3000	1.7196	2.1557	52.9116	0.3213	0.0039
1560	1.3144	1.7035	2.1517	52.3458	0.2744	0.0033
1570	1.3288	1.6870	2.1475	51.7720	0.2338	0.0028
1580	1.3431	1.6700	2.1431	51.1908	0.1990	0.0024
1590	1.3574	1.6526	2.1386	50.6009	0.1690	0.0020
1600	1.3716	1.6347	2.1339	50.0024	0.1433	0.0017
1610	1.3857	1.6163	2.1289	49.3929	0.1213	0.0015
1620	1.3997	1.5973	2.1238	48.7733	0.1025	0.0012
1630	1.4136	1.5779	2.1185	48.1420	0.0864	0.0010
1640	1.4275	1.5578	2.1129	47.4981	0.0728	0.0009
1650	1.4414	1.5371	2.1072	46.8408	0.0612	0.0007
1660	1.4552	1.5157	2.1012	46.1682	0.0514	0.0006
1670	1.4689	1.4936	2.0949	45.4780	0.0430	0.0005
1680	1.4826	1.4707	2.0883	44.7700	0.0360	0.0004
1690	1.4961	1.4469	2.0813	44.0415	0.0301	0.0004
1700	1.5097	1.4221	2.0740	43.2892	0.0251	0.0003
1710	1.5232	1.3963	2.0663	42.5120	0.0209	0.0003
1720	1.5366	1.3691	2.0581	41.7005	0.0173	0.0002
1730	1.5500	1.3406	2.0493	40.8561	0.0144	0.0002
1740	1.5633	1.3102	2.0398	39.9647	0.0119	0.0001
1750	1.5766	1.2777	2.0293	39.0233	0.0098	0.0001
1760	1.5899	1.2422	2.0176	38.0018	0.0081	0.0001
1770	1.6030	1.2025	2.0039	36.8738	0.0067	0.0001
1780	1.6161	1.1543	1.9860	35.5377	0.0055	0.0001
1781	1.6175	1.1484	1.9837	35.3731	0.0054	0.0001
1782	1.6186	1.1420	1.9810	35.2045	0.0053	0.0001
1783	1.6197	1.1346	1.9776	35.0103	0.0052	0.0001


HollowWorld05.bas a = 900 900<=b<=1,783 c = 1,783
Surface Gravity = 1.62
Gravity (m/s^2)
Air Density (kg/m^3)
Gravity/Air Density
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
Kilometers from Center

This run is for a hollow interior of 1200 kilometers. The thickness of the shell is 583 kilometers. The volume of the hollow interior is 30.4% of the total volume. Presumably, the volume of the interconnected caverns in the shell could account for another 20% of the total volume. This would result in a Moon that was around 50% vacant space.

```
Enter outer radius (c) (km)                : 1783
Enter inner radius (a) a<c (km)            : 1200
Enter surface gravity (gsu) (m/s^2)        : 1.62
Enter STP gas density (pst) (kg/m^3)       : 1.2
Enter interior air pressure (pin) (KPa)    : 100
Enter beginning value of [b] (b) a<=b<=c   : 1200
Enter the ending value of [b](u) b<=u<=c   : 1783
```

b	gx	gy	gn	q	Pressure	Density
0	0.0000				100.0000	1.2000
10	0.0000				100.0000	1.2000
20	0.0000				100.0000	1.2000
30	0.0000				100.0000	1.2000
40	0.0000				100.0000	1.2000
50	0.0000				100.0000	1.2000
60	0.0000				100.0000	1.2000
70	0.0000				100.0000	1.2000
80	0.0000				100.0000	1.2000
90	0.0000				100.0000	1.2000
100	0.0000				100.0000	1.2000
110	0.0000				100.0000	1.2000
120	0.0000				100.0000	1.2000
130	0.0000				100.0000	1.2000
140	0.0000				100.0000	1.2000
150	0.0000				100.0000	1.2000
160	0.0000				100.0000	1.2000
170	0.0000				100.0000	1.2000
180	0.0000				100.0000	1.2000
190	0.0000				100.0000	1.2000
200	0.0000				100.0000	1.2000
210	0.0000				100.0000	1.2000
220	0.0000				100.0000	1.2000
230	0.0000				100.0000	1.2000
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250	0.0000				100.0000	1.2000
260	0.0000				100.0000	1.2000
270	0.0000				100.0000	1.2000
280	0.0000				100.0000	1.2000
290	0.0000				100.0000	1.2000
300	0.0000				100.0000	1.2000
310	0.0000				100.0000	1.2000
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330	0.0000				100.0000	1.2000
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360	0.0000				100.0000	1.2000
370	0.0000				100.0000	1.2000
380	0.0000				100.0000	1.2000

390	0.0000	100.0000	1.2000
400	0.0000	100.0000	1.2000
410	0.0000	100.0000	1.2000
420	0.0000	100.0000	1.2000
430	0.0000	100.0000	1.2000
440	0.0000	100.0000	1.2000
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460	0.0000	100.0000	1.2000
470	0.0000	100.0000	1.2000
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490	0.0000	100.0000	1.2000
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510	0.0000	100.0000	1.2000
520	0.0000	100.0000	1.2000
530	0.0000	100.0000	1.2000
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550	0.0000	100.0000	1.2000
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570	0.0000	100.0000	1.2000
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600	0.0000	100.0000	1.2000
610	0.0000	100.0000	1.2000
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640	0.0000	100.0000	1.2000
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680	0.0000	100.0000	1.2000
690	0.0000	100.0000	1.2000
700	0.0000	100.0000	1.2000
710	0.0000	100.0000	1.2000
720	0.0000	100.0000	1.2000
730	0.0000	100.0000	1.2000
740	0.0000	100.0000	1.2000
750	0.0000	100.0000	1.2000
760	0.0000	100.0000	1.2000
770	0.0000	100.0000	1.2000
780	0.0000	100.0000	1.2000
790	0.0000	100.0000	1.2000
800	0.0000	100.0000	1.2000
810	0.0000	100.0000	1.2000
820	0.0000	100.0000	1.2000
830	0.0000	100.0000	1.2000
840	0.0000	100.0000	1.2000
850	0.0000	100.0000	1.2000
860	0.0000	100.0000	1.2000
870	0.0000	100.0000	1.2000
880	0.0000	100.0000	1.2000
890	0.0000	100.0000	1.2000
800	0.0000	100.0000	1.2000
810	0.0000	100.0000	1.2000
820	0.0000	100.0000	1.2000
830	0.0000	100.0000	1.2000

840	0.0000				100.0000	1.2000
850	0.0000				100.0000	1.2000
860	0.0000				100.0000	1.2000
870	0.0000				100.0000	1.2000
880	0.0000				100.0000	1.2000
890	0.0000				100.0000	1.2000
900	0.0000				100.0000	1.2000
910	0.0000				100.0000	1.2000
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960	0.0000				100.0000	1.2000
970	0.0000				100.0000	1.2000
980	0.0000				100.0000	1.2000
990	0.0000				100.0000	1.2000
1000	0.0000				100.0000	1.2000
1010	0.0000				100.0000	1.2000
1020	0.0000				100.0000	1.2000
1030	0.0000				100.0000	1.2000
1040	0.0000				100.0000	1.2000
1050	0.0000				100.0000	1.2000
1060	0.0000				100.0000	1.2000
1070	0.0000				100.0000	1.2000
1080	0.0000				100.0000	1.2000
1090	0.0000				100.0000	1.2000
1100	0.0000				100.0000	1.2000
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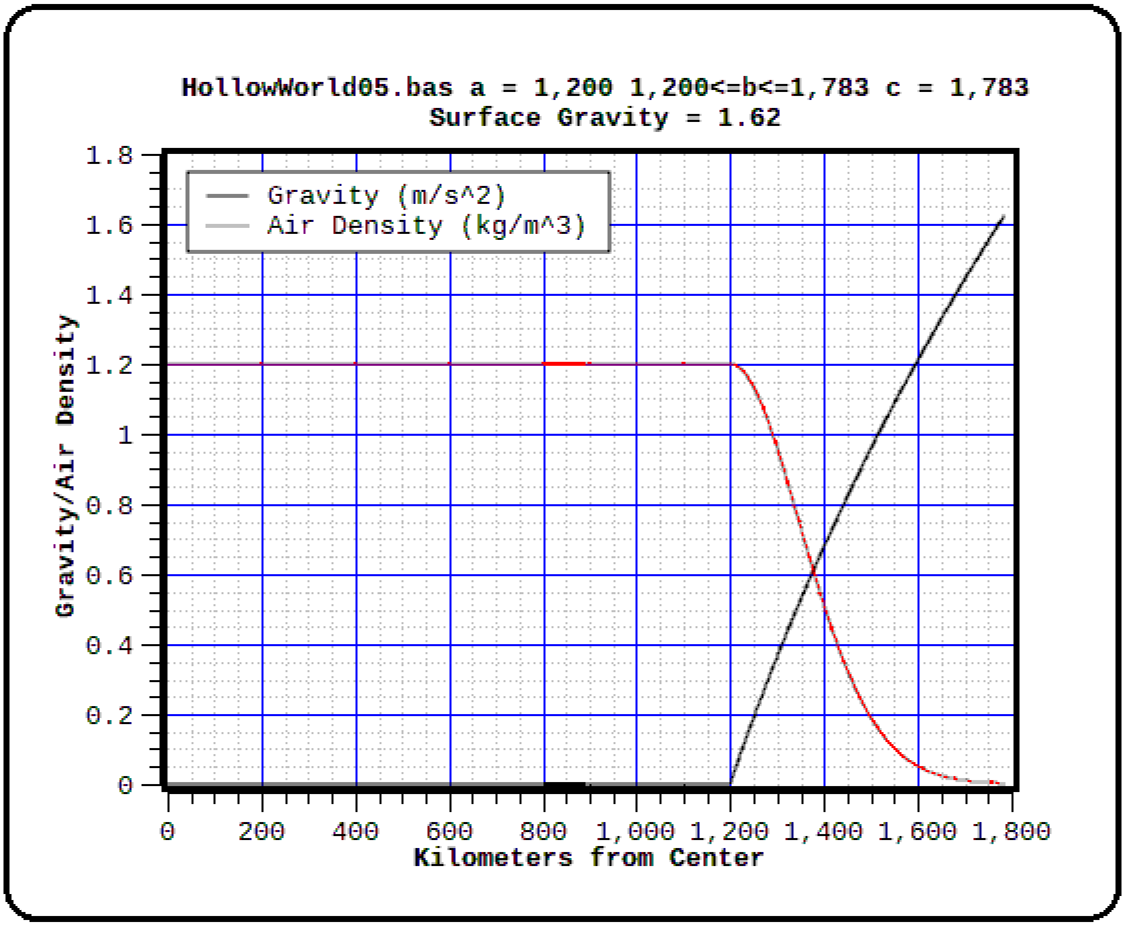
1120	0.0000				100.0000	1.2000
1130	0.0000				100.0000	1.2000
1140	0.0000				100.0000	1.2000
1150	0.0000				100.0000	1.2000
1160	0.0000				100.0000	1.2000
1170	0.0000				100.0000	1.2000
1180	0.0000				100.0000	1.2000
1190	0.0000				100.0000	1.2000
1200	0.0015	1.8366	1.8366	89.9542	100.0000	1.2000
1210	0.0402	1.8858	1.8863	88.7794	99.7733	1.1973
1220	0.0784	1.9193	1.9209	87.6612	99.0878	1.1891
1230	0.1160	1.9460	1.9495	86.5885	97.9596	1.1755
1240	0.1530	1.9680	1.9740	85.5533	96.4106	1.1569
1250	0.1895	1.9866	1.9957	84.5521	94.4676	1.1336
1260	0.2254	2.0024	2.0150	83.5776	92.1615	1.1059
1270	0.2608	2.0157	2.0325	82.6293	89.5269	1.0743
1280	0.2956	2.0270	2.0485	81.7036	86.6006	1.0392
1290	0.3299	2.0365	2.0631	80.7979	83.4216	1.0011
1300	0.3638	2.0444	2.0765	79.9105	80.0296	0.9604
1310	0.3972	2.0507	2.0888	79.0394	76.4649	0.9176
1320	0.4301	2.0557	2.1002	78.1835	72.7673	0.8732
1330	0.4626	2.0594	2.1107	77.3412	68.9759	0.8277
1340	0.4946	2.0620	2.1205	76.5121	65.1279	0.7815
1350	0.5262	2.0635	2.1295	75.6936	61.2586	0.7351
1360	0.5574	2.0639	2.1378	74.8861	57.4009	0.6888
1370	0.5882	2.0634	2.1456	74.0880	53.5849	0.6430
1380	0.6187	2.0619	2.1527	73.2984	49.8376	0.5981

1390	0.6487	2.0595	2.1592	72.5162	46.1832	0.5542
1400	0.6784	2.0562	2.1653	71.7409	42.6423	0.5117
1410	0.7077	2.0522	2.1708	70.9722	39.2324	0.4708
1420	0.7367	2.0474	2.1759	70.2087	35.9679	0.4316
1430	0.7654	2.0417	2.1805	69.4503	32.8601	0.3943
1440	0.7938	2.0353	2.1846	68.6946	29.9174	0.3590
1450	0.8218	2.0282	2.1884	67.9435	27.1452	0.3257
1460	0.8495	2.0204	2.1917	67.1949	24.5468	0.2946
1470	0.8769	2.0119	2.1947	66.4485	22.1231	0.2655
1480	0.9040	2.0026	2.1972	65.7044	19.8727	0.2385
1490	0.9309	1.9927	2.1994	64.9600	17.7929	0.2135
1500	0.9575	1.9821	2.2012	64.2164	15.8792	0.1906
1510	0.9838	1.9708	2.2027	63.4722	14.1259	0.1695
1520	1.0098	1.9588	2.2038	62.7274	12.5262	0.1503
1530	1.0356	1.9462	2.2046	61.9809	11.0728	0.1329
1540	1.0612	1.9329	2.2050	61.2328	9.7575	0.1171
1550	1.0865	1.9189	2.2051	60.4808	8.5719	0.1029
1560	1.1115	1.9042	2.2049	59.7260	7.5073	0.0901
1570	1.1364	1.8888	2.2043	58.9660	6.5550	0.0787
1580	1.1610	1.8726	2.2033	58.2009	5.7063	0.0685
1590	1.1854	1.8557	2.2020	57.4300	4.9527	0.0594
1600	1.2096	1.8381	2.2004	56.6526	4.2859	0.0514
1610	1.2336	1.8198	2.1985	55.8671	3.6980	0.0444
1620	1.2574	1.8005	2.1961	55.0717	3.1815	0.0382
1630	1.2810	1.7805	2.1934	54.2668	2.7292	0.0328
1640	1.3044	1.7595	2.1903	53.4499	2.3346	0.0280
1650	1.3276	1.7377	2.1868	52.6218	1.9913	0.0239
1660	1.3506	1.7149	2.1829	51.7778	1.6937	0.0203
1670	1.3735	1.6911	2.1785	50.9171	1.4366	0.0172
1680	1.3961	1.6661	2.1737	50.0376	1.2151	0.0146
1690	1.4186	1.6399	2.1684	49.1384	1.0250	0.0123
1700	1.4410	1.6124	2.1624	48.2129	0.8622	0.0103
1710	1.4631	1.5835	2.1559	47.2620	0.7233	0.0087
1720	1.4852	1.5527	2.1486	46.2731	0.6051	0.0073
1730	1.5070	1.5201	2.1405	45.2484	0.5049	0.0061
1740	1.5288	1.4852	2.1315	44.1726	0.4202	0.0050
1750	1.5502	1.4476	2.1210	43.0397	0.3488	0.0042
1760	1.5717	1.4061	2.1089	41.8160	0.2887	0.0035
1770	1.5930	1.3592	2.0940	40.4711	0.2384	0.0029
1780	1.6140	1.3017	2.0735	38.8855	0.1963	0.0024
1781	1.6163	1.2945	2.0707	38.6907	0.1925	0.0023
1782	1.6181	1.2868	2.0674	38.4924	0.1888	0.0023
1783	1.6200	1.2778	2.0633	38.2642	0.1851	0.0022

This run indicates that the ideal pressure at the surface is 185.1 Pascals with respect to the given 100 KPa in the interior. This is a 540 fold drop in pressure. However, this is the maximum ideal. A reality would include resistance passing through the shell and finding any openings to the surface to relieve the stack.



Observe how at a hollow radius of 1,200 km and a shell thickness of 583 km, that the reducing air pressure appears to have arrived at a significant point of diminishing returns.

Here is the final run of this series for these hypothetical situations for the Moon. In this final case the thickness of the shell is but 273 kilometers thick leaving a hollow interior with a diameter of 3,000 kilometers.

As a refresher; The first column is the distance from the center in kilometers, the second is the local rate of acceleration due to gravity in meters per second per second. The third column represents the situation of the horizontal rate of acceleration due to gravity in meters per second per second if the counteracting half were removed, the fourth column represents the norm of the second and third column, the fifth column represents the angle that the second and third column make from the vertical with respect to the center of the Moon, the sixth column represents the reduction of atmospheric pressure while passing upward through the shell in KPa, and the seventh column likewise represents the resultant air density in kilograms per cubic meter.

```
Enter outer radius (c) (km)                : 1783
Enter inner radius (a) a<c (km)            : 1500
Enter surface gravity (gsu) (m/s^2)        : 1.62
Enter STP gas density (pst) (kg/m^3)       : 1.2
Enter interior air pressure (pin) (KPa)    : 100
Enter beginning value of [b] (b) a<=b<=c   : 1500
Enter the ending value of [b](u) b<=u<=c   : 1783
   0   0.0000                            100.0000   1.2000
  10   0.0000                            100.0000   1.2000
  20   0.0000                            100.0000   1.2000
  30   0.0000                            100.0000   1.2000
  40   0.0000                            100.0000   1.2000
  50   0.0000                            100.0000   1.2000
  60   0.0000                            100.0000   1.2000
  70   0.0000                            100.0000   1.2000
  80   0.0000                            100.0000   1.2000
  90   0.0000                            100.0000   1.2000
 100   0.0000                            100.0000   1.2000
 110   0.0000                            100.0000   1.2000
 120   0.0000                            100.0000   1.2000
 130   0.0000                            100.0000   1.2000
 140   0.0000                            100.0000   1.2000
 150   0.0000                            100.0000   1.2000
 160   0.0000                            100.0000   1.2000
 170   0.0000                            100.0000   1.2000
 180   0.0000                            100.0000   1.2000
 190   0.0000                            100.0000   1.2000
 200   0.0000                            100.0000   1.2000
 210   0.0000                            100.0000   1.2000
 220   0.0000                            100.0000   1.2000
 230   0.0000                            100.0000   1.2000
 240   0.0000                            100.0000   1.2000
 250   0.0000                            100.0000   1.2000
 260   0.0000                            100.0000   1.2000
 270   0.0000                            100.0000   1.2000
```

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290	**0.0000**	**100.0000**	**1.2000**
300	**0.0000**	**100.0000**	**1.2000**
310	**0.0000**	**100.0000**	**1.2000**
320	**0.0000**	**100.0000**	**1.2000**
330	**0.0000**	**100.0000**	**1.2000**
340	**0.0000**	**100.0000**	**1.2000**
350	**0.0000**	**100.0000**	**1.2000**
360	**0.0000**	**100.0000**	**1.2000**
370	**0.0000**	**100.0000**	**1.2000**
380	**0.0000**	**100.0000**	**1.2000**
390	**0.0000**	**100.0000**	**1.2000**
400	**0.0000**	**100.0000**	**1.2000**
410	**0.0000**	**100.0000**	**1.2000**
420	**0.0000**	**100.0000**	**1.2000**
430	**0.0000**	**100.0000**	**1.2000**
440	**0.0000**	**100.0000**	**1.2000**
450	**0.0000**	**100.0000**	**1.2000**
460	**0.0000**	**100.0000**	**1.2000**
470	**0.0000**	**100.0000**	**1.2000**
480	**0.0000**	**100.0000**	**1.2000**
490	**0.0000**	**100.0000**	**1.2000**
500	**0.0000**	**100.0000**	**1.2000**
510	**0.0000**	**100.0000**	**1.2000**
520	**0.0000**	**100.0000**	**1.2000**
530	**0.0000**	**100.0000**	**1.2000**
540	**0.0000**	**100.0000**	**1.2000**
550	**0.0000**	**100.0000**	**1.2000**
560	**0.0000**	**100.0000**	**1.2000**
570	**0.0000**	**100.0000**	**1.2000**
580	**0.0000**	**100.0000**	**1.2000**
590	**0.0000**	**100.0000**	**1.2000**
600	**0.0000**	**100.0000**	**1.2000**
610	**0.0000**	**100.0000**	**1.2000**
620	**0.0000**	**100.0000**	**1.2000**
630	**0.0000**	**100.0000**	**1.2000**
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700	**0.0000**	**100.0000**	**1.2000**
710	**0.0000**	**100.0000**	**1.2000**
720	**0.0000**	**100.0000**	**1.2000**
730	**0.0000**	**100.0000**	**1.2000**
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750	**0.0000**	**100.0000**	**1.2000**
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770	**0.0000**	**100.0000**	**1.2000**
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790	**0.0000**	**100.0000**	**1.2000**
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810	**0.0000**	**100.0000**	**1.2000**
820	**0.0000**	**100.0000**	**1.2000**

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940	0.0000	100.0000	1.2000
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1250	0.0000	100.0000	1.2000
1260	0.0000	100.0000	1.2000
1270	0.0000	100.0000	1.2000

1280	0.0000				100.0000	1.2000
1290	0.0000				100.0000	1.2000
1300	0.0000				100.0000	1.2000
1310	0.0000				100.0000	1.2000
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1400	0.0000				100.0000	1.2000
1410	0.0000				100.0000	1.2000
1420	0.0000				100.0000	1.2000
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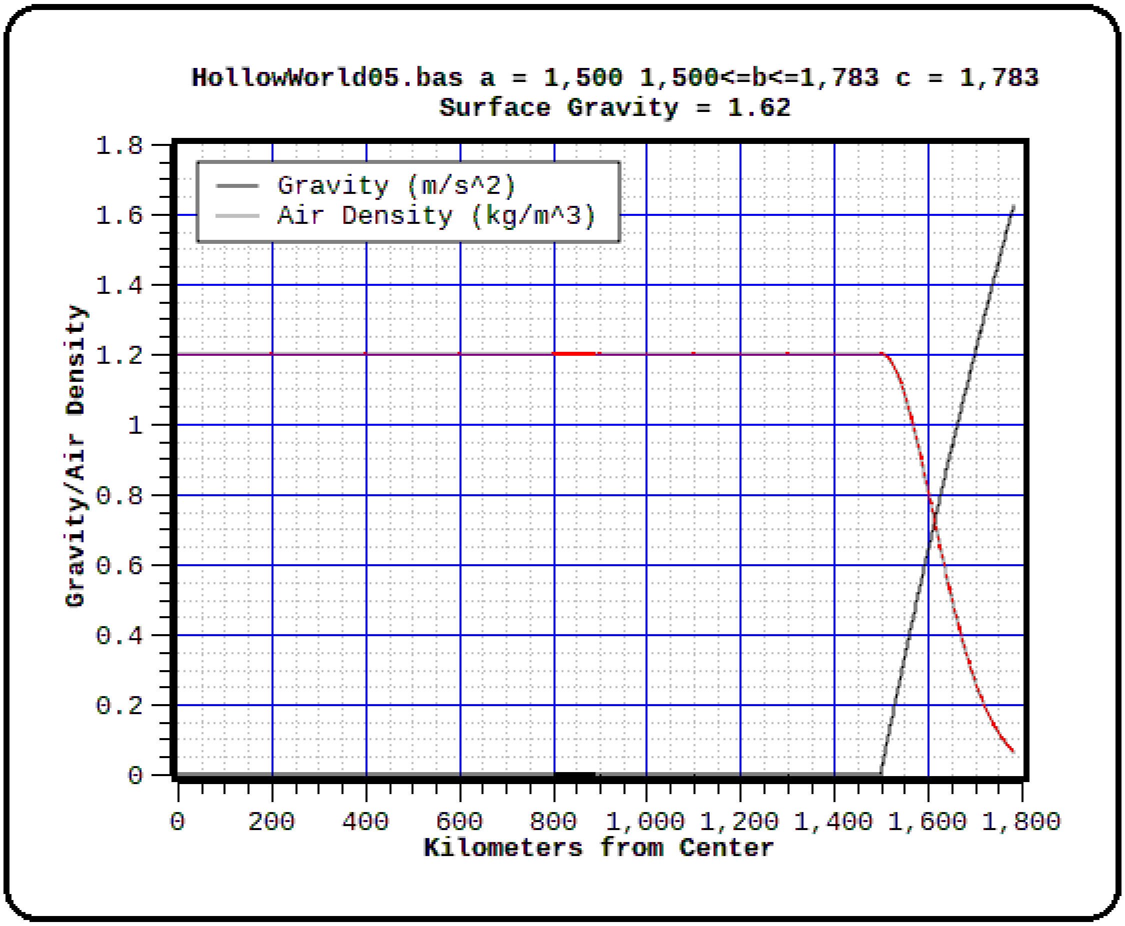
1440	0.0000				100.0000	1.2000
1450	0.0000				100.0000	1.2000
1460	0.0000				100.0000	1.2000
1470	0.0000				100.0000	1.2000
1480	0.0000				100.0000	1.2000
1490	0.0000				100.0000	1.2000
1500	0.0025	1.9113	1.9113	89.9244	100.0000	1.2000
1501	0.0092	1.9223	1.9223	89.7250	99.9970	1.2000
1510	0.0691	1.9880	1.9892	88.0081	99.6103	1.1953
1520	0.1351	2.0374	2.0419	86.2051	98.4341	1.1812
1530	0.2003	2.0748	2.0844	84.4854	96.5077	1.1581
1540	0.2646	2.1039	2.1205	82.8308	93.8846	1.1266
1550	0.3282	2.1267	2.1519	81.2284	90.6322	1.0876
1560	0.3909	2.1443	2.1796	79.6687	86.8291	1.0419
1570	0.4529	2.1570	2.2040	78.1423	82.5622	0.9907
1580	0.5141	2.1659	2.2261	76.6475	77.9235	0.9351
1590	0.5746	2.1710	2.2457	75.1749	73.0066	0.8761
1600	0.6344	2.1727	2.2634	73.7231	67.9044	0.8149
1610	0.6935	2.1710	2.2791	72.2848	62.7062	0.7525
1620	0.7519	2.1665	2.2932	70.8603	57.4955	0.6899
1630	0.8096	2.1589	2.3058	69.4430	52.3481	0.6282
1640	0.8667	2.1485	2.3167	68.0301	47.3309	0.5680
1650	0.9232	2.1351	2.3262	66.6169	42.5005	0.5100
1660	0.9791	2.1190	2.3342	65.2005	37.9038	0.4548
1670	1.0344	2.1001	2.3410	63.7782	33.5768	0.4029
1680	1.0891	2.0781	2.3462	62.3417	29.5456	0.3545
1690	1.1432	2.0533	2.3501	60.8922	25.8269	0.3099
1700	1.1968	2.0252	2.3524	59.4198	22.4288	0.2691
1710	1.2497	1.9941	2.3533	57.9242	19.3518	0.2322
1720	1.3023	1.9589	2.3523	56.3841	16.5898	0.1991
1730	1.3542	1.9200	2.3495	54.8043	14.1319	0.1696
1740	1.4057	1.8764	2.3446	53.1609	11.9623	0.1435
1750	1.4565	1.8277	2.3371	51.4474	10.0627	0.1208
1760	1.5072	1.7716	2.3260	49.6099	8.4125	0.1009
1770	1.5571	1.7055	2.3094	47.6036	6.9898	0.0839
1780	1.6065	1.6209	2.2821	45.2560	5.7724	0.0693
1781	1.6117	1.6098	2.2779	44.9676	5.6612	0.0679
1782	1.6162	1.5980	2.2728	44.6765	5.5517	0.0666
1783	1.6206	1.5839	2.2661	44.3432	5.4440	0.0653

Here is a graph taken from the preceding run. Observe that there is still a considerable amount of air pressure at the surface. Any decent engineer would reject this final situation as too wasteful. Such an engineer would only use a shell thickness of at least 600 kilometers.

In this particular situation the vacant space in the interior represents 59.5% of the total volume of the Moon. There would likely be resulting structural instabilities.



If “our” Moon were indeed a spaceship, or more precisely, a mother ship; It would be highly unlikely that it was the only one. There would most likely be entire fleets of such “mother-ships” spread throughout the universe. To understand the concept we need to put ourselves in the place of the hypothetical engineers.

Within our own known solar system there are six other “moons” attached to three other planets. Let us compare the fundamental attributes of each of these six other moons. We will compare this to “our” Moon.

Luna: Moon of Earth.
Mean distance from Sun = 149,570,000 km.
Mean distance from Earth = 384,403 km.
Mean Radius of Body = 1,728 km.
Mass of Body = 7.3540 * 10^22 kg.
Period of orbit about Earth = 2,360,550 sec = 655.7083 hr = 27.3212 dy.
Period of Solar Day = 2,551,390 sec = 708.7194 hr = 29.5300 dy.
Rate of acceleration due to gravity on surface = 1.62 m/sec^2.
Equilibrium Temperature = 394K = 121ºC

Io: Innermost Moon of Jupiter.
Mean distance from Sun = 778,140,000 km.
Mean distance from Jupiter = 421,900 km.
Mean Radius of Body = 1,726 km.
Mass of Body = 7.87 * 10^22 kg.
Period of orbit about Jupiter = 152,8590 sec = 42.3858 hr = 1.7661 dy.
Period of Solar Day = 159,220 sec = 44.2278 hr = 1.8428 dy.
Rate of acceleration due to gravity on surface = 1.76 m/sec^2.
Equilibrium Temperature = 173K = -100ºC

Europa: Second Moon of Jupiter.
Mean distance from Sun = 778,140,000 km.
Mean distance from Jupiter = 671,200 km.
Mean Radius of Body = 1,488 km.
Mass of Body = 4.78 * 10^22 kg.
Period of orbit about Jupiter = 306,824 sec = 85.2289 hr = 3.5512 dy.
Period of Solar Day = 307,076 sec = 85.2989hr = 3.5512 dy.
Rate of acceleration due to gravity on surface = 1.44 m/sec^2.
Equilibrium Temperature = 173K = -100ºC

Ganymede: Third Moon of Jupiter.

Mean distance from Sun = 778,140,000 km.

Mean distance from Jupiter = 1,071,000 km.

Mean Radius of Body = 2,529 km.

Mass of Body = 1.54 * 10^23 kg = 15.4 * 10^22 kg.

Period of orbit about Jupiter = 618,175 sec = 171.715 hr = 7.1666 dy.

Period of Solar Day = 619,198 sec = 172.000hr = 3.5512 dy.

Rate of acceleration due to gravity on surface = 1.60 m/sec^2.

Equilibrium Temperature = 173K = -100ºC.

Callisto: Fourth Moon of Jupiter.

Mean distance from Sun = 778,140,000 km.

Mean distance from Jupiter = 1,883,000 km.

Mean Radius of Body = 2,416 km.

Mass of Body = 7.35±2.65 * 10^22 kg.

Period of orbit about Jupiter = 1,441,930 sec = 400.53 hr = 16.689 dy.

Period of Solar Day = 43,041 sec = 11.956 hr = 0.4982 dy.

Rate of acceleration due to gravity on surface = 0.84±0.32 m/sec^2.

Equilibrium Temperature = 173K = -100ºC

Observe that all four moons of Jupiter move about precisely on the equatorial plane of Jupiter. Observe further that the three innermost moons appear to always face Jupiter while the fourth outermost moon has a rotational period only slightly greater than Jupiter. This latter is similar to the relation that our own Moon bears to the Sun.

For the record; The mass of Jupiter is given as 1.901 * 10^27 kg, the radius is given as 69,758 km, the sidereal period of rotation is given as 35,410 seconds or 9.836 hours, and the surface gravity is given as 2.601 meters per second per second. The mean temperature is given as 123 K for the night and 313 K for the day. These temperatures as given seem suspicious.

The planetary data was acquired from the 62nd edition of the CRC Handbook of Chemistry and Physics (19812-1982).

Now let us continue on to Titan, the moon of Saturn; and then to Triton, the moon of Neptune.

Titan: Moon of Saturn.

Mean distance from Sun = 1,427,000,000 km.

Mean distance from Saturn = 1,227,000 km.

Mean Radius of Body = 2,379 km.

Mass of Body = 1.19±0.55 * 10^23 kg = 11.9±5.5 * 10^22 kg.

Period of orbit about Saturn = 1,379,120 sec = 383.09 hr = 15.962 dy.

Period of Solar Day = 1,381,170 sec = 383.66 hr = 15.986 dy.

Rate of acceleration due to gravity on surface = 1.40±0.69 m/sec^2.

Equilibrium Temperature = 128K = -145°C

This data on Titan indicates that Titan always shows the same face to Saturn. There is indicated an extreme uncertainty concerning the mass and the surface rate of acceleration due to gravity. This is a similar situation to Callisto, the 4th moon of Jupiter. This may be due to resolution and light gathering issues in detecting passing point masses (i.e. comets, etc) that are effected by the mass of Titan. This issue is important.

Triton: Moon of Neptune.

Mean distance from Sun = 4,499,000,000 km.

Mean distance from Saturn = 353,100 km.

Mean Radius of Body = 2,008 km.

Mass of Body = 1.46 * 10^23 kg = 14.6 * 10^22 kg.

Period of orbit about Saturn = R 507,712 sec = 141.03 hr = 5.876 dy.

Period of Solar Day = R 507,663 sec = 141.02 hr = 5.876 dy.

Rate of acceleration due to gravity on surface = 2.41 m/sec^2.

Equilibrium Temperature = 72K = -201°C

If our Moon were indeed a “Mother-Ship” of one or more space-faring races, it is highly unlikely that it would be the only one. In practice, there would probably be thousands, possibly millions. In this case, the seven named Moons would be as the great “flagships” of the fleet.

A “flagship” is rarely powered up. It is usually quite large and acts as a self-contained home for the crew. A great burden and responsibility lies on the captain. The vessel is so large that it becomes a menace to the harbor and the other craft when it is powered up and underway. It is normally anchored in a strategic location so that smaller vessels may come and go.

The great question is why would anyone go to the trouble of remaking planetoids into spacecraft?

The human eye has three great limitations. These are light sensitivity, spectrum sensitivity, and resolution of images. We all live in a balance of these three limitations. In truth, without these limitations we would be so overwhelmed with irrelevant images from far away that we be in a blind fog when taking care of our immediate and essential business close at hand.

We have created artificial devices to overcome our visual limitations. These devices will normally enhance one attribute at the expense of another. Thus if we look through a telescope at a distant planet, we will better resolve the image, but normally at a loss of the light sensitivity. The maximum aperture of the human pupil is around 5mm. The most common binocular is the 7x35. The magnification is 7x while the objectives are 35mm. This resolves to a pupil index of 5mm, the same as the average human eye. At sea a variant of 7x50 is used. This has the same magnification but has a pupil index of around 7.1mm. This doubles the light gathering capacity to double what the eye can normally detect. When using these binoculars to look at the heavens, we can see out 1.41 times further for the same amount of light being emitted. With these marine binoculars we can ideally see 2.82 times as many stars at 7 times the resolution. However, this does not account for system losses. A magnification of seven is about the maximum that a person may employ without actually losing resolution due to vibration. A 10x50 pair of binoculars has a pupil index of 5mm like the 7x35, but the vibrations while holding it tend to blur the image resulting in a loss of resolution. Our great telescopes need to be heavily built on a heavy foundation with minimal tolerances.

The radiation emitted by a “main sequence” star normally varies as about the cube of the mass. Our definition of where a star begins is purely anthropomorphic. Thus, we consider the beginning mass of a star to be around 1/10 of the mass of the Sun when our eyes may first detect what we call “red.” This a clear case of arrogant naivete. Now even our aforementioned “red” star will produce 1/1,000 of the radiation of the Sun using 1/10 of the mass. The “red” star may expect a life expectancy of 100 times greater than the Sun. This “red” start would support an Earth-like planet at a distance of about 4,500,000 km. We can see stars like our Sun out to around 40 LY. We can see “red” stars of 1/10 of the mass of the Sun out to around 1.26 LY. Past out natural limitations we must use probability and imagination. We must extend our “sample” space beyond normal space. In doing so, we find that “empty space” is quite crowded.

The original of our intrepid space-farers would have long ago considered these arguments.

In the depths of interstellar space there are countless worlds that we can never detect. While the light from the self-luminous bodies varies inversely as the square of the distance, the reflected light from the most distant planets in our own solar system varies jointly directly as the albedo, the square of the radius, and inversely as the fourth power of the distance. This latter is an outer limit comprising the reduction of light from the Sun which is by the square of the distance compounded by the reduction of the light reflected back to us which also varies as the square of the distance.

Massive Suns are rare. Even Suns like our own are really not that common. However, such Suns make a big show. In the shadows beyond, there are “red” Suns and “thermally radiant” Suns. There are countless planets like Jupiter and far more like the Earth. Planetoids like the Moon are even more common, even if we cannot detect them. Then we have the asteroidal class of bodies that fill the depths of interstellar space.

An ancient species expanding from its home-world would see the limitless possibilities. Now we come to the oft ignored spiritual issue. I am not speaking of organized religions are strange cults. I am speaking of the consciousness that gives direction to the body, an entity that transcends the corruptible body. The issue is what happens to the spirit upon the dissolution of the body in deep space, far from home. This question was probably as unanswerable then as it is now. However, the solution is simple. You take your entire people with you as a “tribe.” Bodies can be “created” in form according to the physical need. A good creator will never make the creation perfect. There must be a directed imperfection that will allow for natural selection (evolution). This will supply the bodies for the plants, the animals, and the masters of the plants and the animals. It will not supply the driving spirit (the soul).

It is possible for a plant to be created that would thrive on a longer wavelength of radiation, such as in the interior of a hypothetical spaceship moon. Within such a body, energy would be constantly recycled even if it were not evident on the exterior. However, in the depths of deep space our countless vagabond planetoids would be subjected to extreme entropy. We need to naturally and reliably warm the interior spaces.

Mixed in with all the heavier elements that comprise the rocks that make up a planetary body there is a trace amount of Thorium and Uranium. These two elements were formed in the heart of great stars that imploded as supernovas.

Stars are driven by fusion energy. That is to say, the fusion of hydrogen into helium. This of course an overly simplistic statement. This fusion occurs at unimaginably high pressures. The process of fusion does not end with helium. It continues on with lesser yields of energy terminating with the production of common iron-56. In an extremely massive star the fusion process will continue past iron, but in so doing, will add energy to the elements higher than iron. This will normally continue all the way up to Uranium. However, once the process goes beyond the formation of lead, it becomes very unstable and can only be maintained within the core of the star.

When a massive star explodes, or implodes, it casts the heavy elements out into space, and away from the environment that maintained them. Many unknown elements are immediately degenerated in the process. The heavy elements below Thorium are relatively stable with an extremely low rate of decay. The heavy elements above Lead and below Uranium are semi-stable and decay with a half-life measured in billions of years, terminating with common Lead. The most prominent of these are Uranium with a half-life of 4.5 billion years and Thorium with a half-life of 13 billion years. Radon and Radium are both relatively short lived intermediaries. The final unobtainable product of this decay in common iron. Iron represents the zero point in the entropic process.

Within the bodies of our hypothetical fleet of planetoids cum mother-ships, there will be a considerable amount of Thorium and Uranium undergoing natural decay, terminating with common lead. The formation of the lead acts as a natural radiation shield. This internal radioactive decay warms the bodies from within.

The heat produced by the radioactive decay will be released at the surface of the body into space as thermal radiation. The rocks and the caves near the surface will act as as an insulating medium. In the cold of interstellar space, there will be an initial temperature gradient that will taper down with the increase in depth. This now brings us to a curious item. Assuming that the amount if Uranium and Thorium is statistically fixed with relation to the other heavy elements, the heat produced by any particular body will very by the cube of the radius while the release of the heat will vary as the square. Thus, a planetoid too small may be very cold while a planetoid too large maybe very high. The engineers would want something in the middle. This could be an explanation as to the reason that our hypothetical suspects are all in the same range of mass and radius.

The internal operations would be founded on self-contained thermal recycling.

How would such a monstrosity be moved. Let us examine this from the viewpoint of some elementary physics, but with a twist.

Our children are taught physics with an emphasis on the “conservation of energy.” This is find as long as it is made clear that the physics and the associated mathematics are used to describe “involuntary” actions and reactions.

Here is the twist. To “power-up” is a “voluntary” action. It is a process where an intelligence has deliberately created an unnatural force that requires the continual application of power and energy. Let us now work from the one to the other. We will be like a trapped mouse gnawing its way from the inside of a box to freedom on the outside of the box.

There was a time that I became interested in amateur rocketry. Amateur rocketry is not about the toy ‘Estes’ model rockets that are sold to entice young children to become fans of the government aerospace projects. Amateur rocketry is about non-government, non-academic, and non-industrial associated persons designing, building, and launching rockets and other associated aeronautical devices to great altitudes on their own.

In order to design a rocket, there are certain things that must be accounted for. The leading points and the leading edges all need to be “raked” to a sharp point or a sharp edge in order to increase the velocity of the sound barrier. The shape of the device and the materials used have to be accounted for with regards to aerodynamic resistance. The mass of the device must be accounted for. The local “spot” rate of acceleration due to gravity must be accounted for. This is all elementary stuff.

I needed a formula for the required power and energy for a subjective rate of acceleration not associated with the local acceleration due to gravity. A rocket freed from the Earth has no knowledge of, or interest in, the rate of acceleration due to gravity. The rocket exists in its own independent domain; (until the two independent domains collide, at which point a new composite domain is created).

I went back to my elementary Newtonian physics as a guide. In the following illustration the mass is ignored and assumed to have a value of one in any unit. It is the acceleration, velocity, and time that is of concern. The mass may be factored in later. This is the well known “Inclined Plane” lesson.

The variables (VAR) for the illustration need to be defined:

VAR [g] = Acceleration due to Gravity.

VAR [h] = Vertical Height of the inclined plane.

VAR [l] = Length of slope.

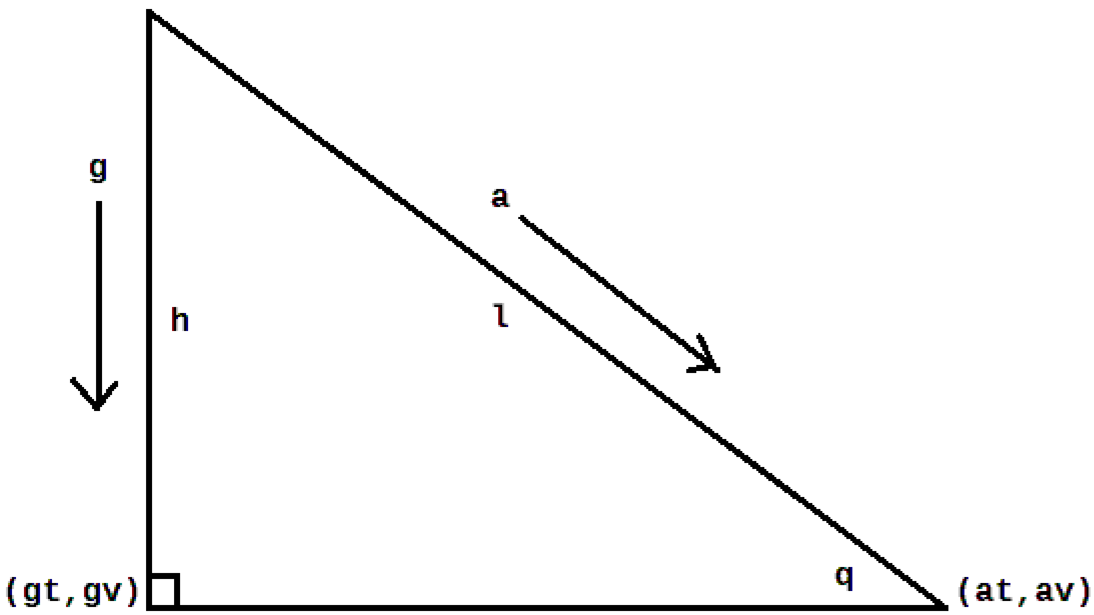
VAR [a] = Acceleration along slope [l].

VAR [gt] = Time of fall due to direct influence of gravity.

VAR [gv] = Final velocity of fall due to direct influence of gravity.

VAR [at] = Time of slide down the slope.

VAR [av] = Final velocity of slide down the slope.



$$h = \frac{g \cdot gt^2}{2} \quad gt = \sqrt{\frac{2 \cdot h}{g}} \quad gv = g \cdot gt \quad h = gt \cdot gv \quad a = g \cdot \sin(q)$$

$$l = \frac{a \cdot at^2}{2} \quad at = \sqrt{\frac{2 \cdot l}{a}} \quad av = a \cdot at \quad l = at \cdot av \quad l = \frac{h}{\sin(q)}$$

$$\int (g \cdot gt)\, d(g) = \frac{g^2 \cdot gt}{2} \qquad \int (g \cdot gt)\, d(gt) = \frac{g \cdot gt^2}{2} = h$$

$$\int (a \cdot at)\, d(a) = \frac{a^2 \cdot at}{2} \qquad \int (a \cdot at)\, d(at) = \frac{a \cdot at^2}{2} = l$$

$$at = \sqrt{\frac{2 \cdot l}{a}} = \sqrt{\frac{2 \cdot \frac{h}{\sin(q)}}{g \cdot \sin(q)}} = \sqrt{\frac{2 \cdot h}{g \cdot \sin(q)^2}} = \frac{\sqrt{\frac{2 \cdot g}{h}}}{\sin(q)} = \frac{gt}{\sin(q)}$$

$$av = a \cdot at = (g \cdot \sin(q)) \cdot \left(\frac{\sqrt{\frac{2 \cdot g}{h}}}{\sin(q)} \right) = g \cdot \sqrt{\frac{2 \cdot g}{h}} = g \cdot gt = gv$$

The primary purpose of this exercise is to demonstrate conservation of energy to the young student. It is a closed system upon itself. It will be observed that the final velocity in both cases is identical. It will also be observed that the time to slide down the slope with respect to the time for a direct fall is proportionate to length of the slope with respect to the height.

I have taken the liberty to include a bit of elementary calculus to the model. Any differential or any integral of any real world function that can be mathematically coded must also represent a real world function. It is up to the student to determine the real world representation. I have shown that one of the two possible integrals of **[time x acceleration = velocity]** is representative of length as a joint function of time and acceleration. There is a second integral to this same function that is often ignored. I will attempt to correct this shortcoming.

The second elementary lesson in physics as taught to our school children, when they aren't practicing hiding under desks, takes the preceding lesson and adds a mass variable to it. This is the "force", "work", and "power" lesson. It is a natural extension of the inclined plane.

"Force" is defined as the product of the rate of acceleration and the mass. On the surface of the Earth the rate of acceleration due to gravity is 32 feet per second per second. A sweet, charming, young lady with a mass of 100 pounds will press down on the surface of the Earth with a gravitational force of 3,200 slugs [32 x 100 = 3,200]. However, do not tell this to the young lady as she will be extremely unappreciative, and will be quite likely to temporarily lose the sweet and charming attributes of her character. Of course if you the SI instead of the SAE, The young lady will have a mass of 45.4 kg and the rate of acceleration will be only 9.8 m/s/s. In the latter case, the young lady will press down on the surface of the Earth with a force of only 445 N [9.8 x 45.4 = 445]. This is still considerably more than 100, so the best advice is to keep your mouth shut and act dumb!!!

In the inclined plane the force of acceleration acting on a given mass will always be proportion to the rate of acceleration which in turn will vary as the sine of the slope with respect to the horizontal.

"Work" is defined as the potential energy represented by the product of the force acting on the mass and the distance.

"Power" is defined as the realized energy of work pro-rated to unit interval of time.

This illustration uses the same basic diagram as in the preceding illustration. Here the conservation of the work potential and the kinetic energy is demonstrated. Since the preceding conservation equations clearly demonstrate that the attributes of the slope are wholly controlled by the attributes of the vertical case, there was no need to separate the two types of situations. Thus, the classical value for acceleration is given as the acceleration due to gravity and the length along the slope is given as the classical difference in the vertical altitude.

m = mass   a = rate of acceleration due to gravity   h = height

f = force of gravity   w = potential work   p = realized power

v = final velocity   k = kinetic energy   t = elapsed time

$$t = \sqrt{\frac{2 \cdot h}{g}} \qquad v = g \cdot t = g \cdot \sqrt{\frac{2 \cdot h}{g}} \qquad v^2 = \left(g \cdot \sqrt{\frac{2 \cdot h}{g}}\right)^2 = 2 \cdot g \cdot h$$

$$f = m \cdot g \qquad w = h \cdot f = m \cdot g \cdot h \qquad p = \frac{w}{t} = \frac{h \cdot f}{t} = \frac{m \cdot g \cdot h}{t}$$

$$\frac{w}{k} = 1 = \frac{m \cdot g \cdot h}{k} = \frac{m \cdot \frac{2 \cdot g \cdot h}{2}}{k} = \frac{\frac{m \cdot v^2}{2}}{k} \qquad k = \frac{m \cdot v^2}{2}$$

Bear in mind that this is a closed system that is controlled by a singular acceleration due to gravity. The rate of acceleration and the final velocity on the slope is wholly governed by the rate of acceleration due to gravity.

The preceding two classical lessons are all both mathematically correct in their own domain and widely demonstrated in the real world. This is all “master/slave” responses where all the actions follow the path of zero resistance. However, this model does not account for “voluntary” actions that are resisted by the natural world. The so called “rocket science” represents the physics that result from voluntary actions.

Before going further, there is another natural zero resistance to consider. This is the classical “Newton’s Cradle” consisting of five steel balls of equal mass and diameter gently resting in series against one another. If one ball is dropped at one end, one ball will be kicked out at the other end. Two balls in and two balls out, three balls in and three balls out, etc. It is a simple demonstration that mass is always subservient to velocity.

So far everything has been “Inside the Box” as commonly taught in our public schools and universities. We now come to the walls of the Box.

For calculating the power and energy required for a voluntary act of acceleration on a level plane or in a free-fall situation; only mass, time, acceleration, and velocity matter. Length is not of immediate concern. The required power for a voluntary act of acceleration also represents the inherent resistance to the same voluntary act of acceleration.

The base here is the time element. This problem will be examined from a viewpoint of a series of duplicate events, each event occurring in one unit of time respectively. Each of the duplicate events will represent power and the collective will represent the total energy. Observe that the time element is given as both VAR [u] and VAR [t]. The former is a special situation to include the unit time of [1] in order to balance out the unit analysis.

There will be the three different approaches yielding the same result. The work approach, the kinetic energy approach, and the momentum approach. Let us begin with the work approach.

u = 1 unit of time   m = mass   a = rate of acceleration

t = elapsed time   p = power   w = work

v = velocity   e = efficiency = w/v

$$f = m \cdot a$$

$$l = \frac{a \cdot u^2}{2}$$

$$p = f \cdot l = (m \cdot a) \cdot \left(\frac{a \cdot u^2}{2}\right) = \frac{m \cdot a^2 \cdot u^2}{2} = \frac{m \cdot a^2}{2} \cdot \left(u^2\right)$$

$$w = p \cdot t = \frac{m \cdot a^2 \cdot u^2 \cdot t}{2} = \frac{m \cdot a^2 \cdot t}{2} \cdot \left(u^2\right)$$

$$v = a \cdot t$$

$$e = \frac{w}{v} = \frac{\dfrac{m \cdot a^2 \cdot t}{2} \cdot \left(u^2\right)}{a \cdot t} = \frac{m \cdot a}{2} \cdot \left(u^2\right)$$

Let us examine the case for the sum of the units of kinetic energy.

u = 1 unit of time   m = mass   a = rate of acceleration

t = elapsed time   p = power   w = work

v = velocity   s = velocity achieved in one time unit

k = unit kinetic energy   e = efficiency = w/v

$$s = a \cdot u$$

$$p = k = \frac{m \cdot s^2}{2} = \frac{m \cdot (a \cdot u)^2}{2} = \frac{m \cdot a^2 \cdot u^2}{2} = \frac{m \cdot a^2}{2} \cdot \left(u^2\right)$$

$$w = p \cdot t = \frac{m \cdot a^2 \cdot u^2 \cdot t}{2} = \frac{m \cdot a^2 \cdot t}{2} \cdot \left(u^2\right)$$

$$v = a \cdot t$$

$$e = \frac{w}{v} = \frac{\frac{m \cdot a^2 \cdot t}{2} \cdot \left(u^2\right)}{a \cdot t} = \frac{m \cdot a}{2} \cdot \left(u^2\right)$$

As we can see, the results are identical to the preceding. Finally, let us take a look at the integral of momentum. Observe that momentum is defined as the product of the mass and the velocity, i.e. [momentum = mass x velocity].

t = elapsed time   m = mass

a = rate of acceleration   v = velocity

$$\text{momentum} = m \cdot v = m \cdot (a \cdot t) = m \cdot a \cdot t$$

$$\int \text{momentum } d(a) = \int (m \cdot a \cdot t)\ d(a) = \frac{m \cdot a^2 \cdot t}{2}$$

As we may clearly see, the integral equation derived from the equation for momentum with respect to acceleration is identical to the two preceding work formulas less the superfluous units of the unit time.

Sir Isaac Newton undoubtedly reached these same conclusions. There are some anomalies that defy established conventions, in Newton’s time and in our time. In Newton’s time and place a person could be publicly burned alive at the stake for speaking against the established conventions. Today, a person would simply be branded a “crackpot” and ignored. It appears that Newton deftly sidestepped the issue in the second to last paragraph of the third book of his great and iconic work, “The Principia.” The solution is so simple that it is very unlikely that Newton did not work it out. This is where the little mouse gnaws through the walls of the box to reveal a much greater world beyond. This is where the little mouse risks cerebral overload and insanity!!!

Here is the issue. It appears that the power required to drive a voluntary acceleration of a mass will vary as the square of the rate of acceleration. This is contradictory to “common sense.” “Common sense” is demonstrated on a billiard table when the balls collide, or when the steel balls of Newton’s Cradle collide. It also appears that the energy to achieve a given velocity while undergoing a voluntary acceleration will vary directly as the rate of acceleration. All this indicates that there are other motions in the universe that we are generally unaware of. This goes back to the older argument of whether the Celestial Sphere rotates about the Terrestrial Sphere or whether the Terrestrial Sphere rotates inside of the Celestial Sphere.

Consider this little demonstration. While riding aboard a train, place an inclined place at right angles to the direction of travel. Place a marble at its top and let it go. Now be aware that as you are doing this, that your fellow passengers will all imagine that you have “lost your marbles”, pun intended! As the marble accelerates down the inclined plane it will appear to arc towards the back of the train. If it were moving at a steady velocity it would appear to travel in a straight line cross-ways to the direction of travel of the train. Now imagine that the car has no windows and is sound proof and vibration proof. This latter is the condition that we find ourselves in the conventional box. As a side note; this effect could be used as a motion detector to determine unseen motions.

It is time to go outside the Box.

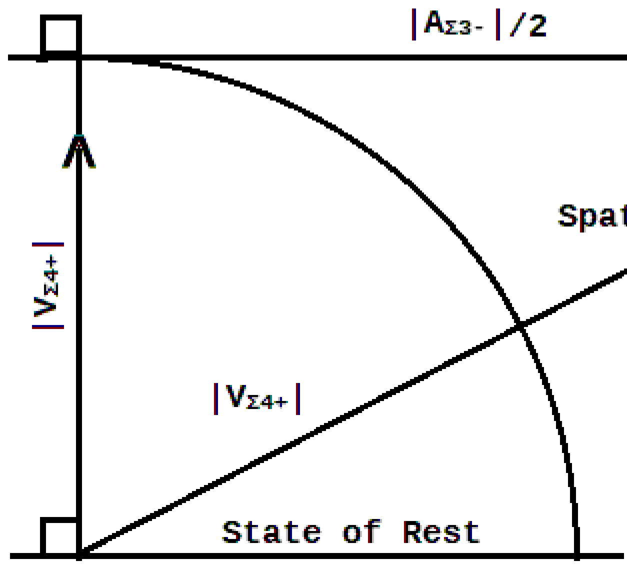
This is where we enter the realm of metaphysics. Metaphysics can be a dangerous territory filled with self-imposed delusions and misdirectons. The simplest aspects of metaphysics are reasonably safe. They are akin to backing a single trailer. The more involved aspects of metaphysics are more like trying to back up two or more trailers. There is a good reason why Isaac Newton publicly steered away from metaphysics and only published that which could be demonstrated by self-evident experimentation.

As the preceding evidence has indicated, the power required for a subjective rate of acceleration varies as the square of the rate of acceleration. Likewise, the energy required to accelerate to a given velocity also varies as the rate of acceleration. A young child learns this not in the classroom, but on the playground during recess. However, the child does not know that he knows. All he is doing is learning the trick of self-propelling a swing which according to Newtonian conservation as taught in the classroom is impossible! I have personally, unassisted, caused the ultimate adult swing set to repeatedly go over the top. It was a steel box known as the “Swinging Gym”, a non-motorized “ride” at fairs usually relegated to the far edge of the fairgrounds away from the bright lights of the Midway, along with the archery and other traditional activities!

In the metaphysical realm we must use our imagination to look at the possibilities. We should always consider the simplest possibilities first as those tend to be of an involuntary nature. However, we should never overlook the voluntary possibilities as well, howbeit we have no real knowledge of the political situations in the metaphysical environment. So with bit of warning, I will produce the simplest possibilities. I will attempt to only back up one trailer.

Imagine that there are more than three dimensions to space. Imagine that the universe that we are cognizant of is but a three-dimensional “skin” traveling through a “multiverse.” Imagine that we are not cognizant of any effects resulting from our motion through the component vectors that agree with the three-dimensional vectors that we are cognizant of. Finally, imagine that we are cognizant of the effects of the components of our imagined multiversal motion that are at right angles to to every direction that we are cognizant of. This latter is the hyperspatial vector that we will be exploring.

Here is a simple illustration of a multiversal application. The horizontal component represents the distance traveled in one unit of time as a consequence of accelerating in any direction that we are cognizant of. The vertical component represents the norm of all possible hyperspatial velocity vectors. The “State of Rest” represents a Newtonian situation where no outside force is present. The remaining “Spatial Tension” represents the effective resistance to the act of acceleration.



Observe that the “Spatial Tension” will vary as the square of the rate of acceleration when the rate of acceleration approaches zero. Likewise, observe that the “Spatial Tension” will vary as the rate of acceleration when the rate of acceleration approaches infinity. The former agrees with the previously calculated formulas while the latter is indicated by the actions demonstrated by “Newton’s Cradle.”

Let us now power-up our hypothetical spaceship Moon for a departure to another star. This may be done by a simple application of “anti-gravity”, the secret of which lies in the preceding illustration, and/or, a simple “space-drive”, whose principles of operation likewise lie in the preceding illustration. Bear in mind that entities who travel about in planetoid size mother-ships that remain in orbit for tens of thousands of years or longer will have a different concept of time than we do.

Our Moon has a given mass of 7.3540 * 10^22 kg. We wish to initially accelerate it to one meter per second and a subjective rate of acceleration of 0.000001 meters per unit second per elapsed second. This is about 1/10,000,000 of one gravity on the surface of the Earth. It will require 11.57 days to reach this velocity.

$$\text{Power} = \frac{\left(7.3540 \cdot 10^{22} \cdot \text{kg}\right) \cdot \left[\left(0.000001 \cdot \frac{\text{m}}{\text{s}^2}\right)^2\right]}{2} = 3.677 \times 10^{10} \, \frac{\text{kg}\,\text{m}^2}{\text{s}^4}$$

$$\text{Orbital Velocity of Earth} = \frac{\left(149570000000 \cdot \text{m}\right) \cdot \left(2 \cdot \pi\right)}{\text{yr}} = 29780.341 \, \frac{\text{m}}{\text{s}}$$

$$\text{yr} = 3.156 \times 10^7 \text{s} \qquad \frac{\left(29783.341 \cdot \frac{\text{m}}{\text{s}}\right)}{\left(0.000001 \cdot \frac{\text{m}}{\text{s}^2}\right)} \cdot \frac{1}{\text{yr}} = 943.797$$

This illustration indicates that at a rate of acceleration of 1 millionth of a meter per second per second, it would require 943.797 years for the Moon to accelerate to velocity equal to the orbital velocity of the Earth about the Sun. However, since the Moon is already in orbit about the Sun, only about 41% of that time would be actually required to reach escape velocity with respect to the Sun. The drive system would be putting out around 36,770,000 kilowatts of power.

Only an insignificant fraction of this power would be required to manipulate the hypothetical spaceship Moon in its combined polar rotation, its orbit about the Sun, and its orbit about the Earth.

This concludes my personal spin on the theory of hollow worlds and the spaceship Moon hypothesis. I have deliberately pulled some of the punches. If you wish to write a blood and thunder, (thud and blunder), novel using this brief study as a reference, feel free to do so. Just send me an autographed copy for my own enjoyment. If you want to start a cult, I will say neither yea nor nay, however, I would like to see the copy of it if it includes some good fantasy artwork, preferably done up in oils. I am partial to fantasy art done up in oils.

Patrick Richard Ahmatov

Thu 21 Mar 2024