

KG

11366

v.926

Volume I



Plate

1980

1981

2009



Harvard Lunar Plates

Measures and Reductions

Mary Fowler

Volume I

Plate No.	Date	Page
1980	1912 Aug. 31	1.
1981	1912 Aug 31	11
2009	1912 Sept. 25	20

15

1

10

23

12

2

13

2

2

1980 Stars measures.

1913 Dec 5.

	d	4	v	d	2	w
1	20100	15009		18973		14688
10.5	15890	921108		1351205		1013030
234	9597	02		08		2130
	38	90		61		84
	<u>23.4222</u>	<u>.4209</u>		<u>10.4541</u>		<u>.4559</u>
2						
23.3	19594	17850		18693		18013
9.6	1314144	14279		1172010		1497073
	50	7579		10		70
	73	40		79		08
	<u>9.6435</u>	<u>.6432</u>		<u>23.3030</u>		<u>.3040</u>
3						
23.9	17390	20048		12776		895550
27.8	914938	18280		1197979		49
	40	8990		7879		8162
	81	38				
	<u>27.8240</u>	<u>.8240</u>		<u>23.9203</u>		<u>.9211</u>

Grade 3.

1980

Star Measures

1913 Dec 5

	d	4	n	d	2	n
1	20100	15009		18973	14688	
105	15890	921108		1351205	1013030	
239	9597	02		08	2130	
	38	90		61	84	
	<u>23.4222</u>	<u>4209</u>		<u>10.4141</u>	<u>4159</u>	
2						
233	19594	17850		18693	18013	
9.6	1314144	1427979		1172010	1497073	
	50	7579		10	70	
	73	40		79	08	
	<u>9.6435</u>	<u>6432</u>		<u>23.3030</u>	<u>3040</u>	
3						
239	17390	20048		12776	895550	
27.8	914938	1828090		1197979	49	
	40	8990		7879	8162	
	81	38				
	<u>27.8240</u>	<u>8240</u>		<u>23.9203</u>	<u>9211</u>	

Grade 3.

1980

Moon Measures.

2

	α	δ	μ	α	δ	μ
1	16321		16583			
18.0	10011	10	12900			
16.6		10	9080			
		19	73			
	<u>16.6310</u>		<u>.6311</u>			

2
18.4
17.0

3
18.8
18.0

4
18.8
18.3
max
in
26

5
18.7
19.0

6
18.0 19910
19.9 10970 75
69
98
19.8928

14420
13290 11
1213
20
8887

15327
93000
0100
15
18.3981

15509
13783 80
6680
09
18.8268

14479
1284138
38
70
18.8362

14411
1145580
8070
20
18.7057

17468
1345070
4951
62
.4011

16532
826058
39
29
.8278

15540
714549
40
21
.8383

15580
854521
19
82
.7063

1980

Moon measures

2

	α	δ	μ	α	δ	μ
1	16321		16583			
180	10011	10	12900			
146		10	9080			
		19	73			
	<u>166310</u>		<u>6311</u>			

2
184
17.0

3
188
18.0

4
188
183
max
2

5
187
19.0

6
180 19910
199 10970
6975
98
19.8928

14420
1329011
1213
20
8887

15327
93000
0100
11
18.3981

15509
1378380
6680
09
18.8268

14479
1284138
38
70
18.8362

14411
1145580
8070
20
18.7057

17468
1345070
4951
62
4011

16532
826058
39
29
8278

15540
714549
40
21
8383

15580
854521
19
82
7063

1980

Moon-measures.

3

	d	n	d	n
1	18198	16426		
17.0	15689	889905		
w.3	80	08		
max	90	10		
	<u>20.2533</u>	<u>.2490</u>		

8 scratch

16.5	18235	18458	17892	16015
w.2	1606070	1063339	1253230	1138050
	60	33	30	88
	25	53	78	01
	<u>20.2170</u>	<u>.2181</u>	<u>16.4646</u>	<u>4625</u>

max in y = 20.2535

1980 Inwon - measure

	d	u	d	x	u
2	18198	16426			
170	15689	889905			
w3	80	08			
max	90	10			
	<u>20.2533</u>	<u>2490</u>			

8 scratch

165	18235	18458	17892	16015
202	1606070	1063339	1253230	113805
	60	53	30	885
	25	53	78	01
	<u>20.2170</u>	<u>2181</u>	<u>16.4646</u>	<u>4625</u>

max in y = 20.2535

1980 Times etc.

Ephemeris 1912 Aug 31	1 ^h 32 ^m	✓	- 1 ^h 44 ^m	✓
" Moon	1 38	✓	19.1	✓
clock slow	1 01.6	✓		
H sid T.	1 39	✓	20.85	✓
H long	4 44	✓	31.05	✓
G sid T.	6 23	✓	51.90	✓
Sid T. in hour	10 37	✓	10.73	✓
Interval	19 46	✓	41.17	✓
Reduction	3	✓	14.41	✓
G. M. T.	19 43	✓	26.76	✓
			G - α = - 0 ^h 07 ^m	✓

From Kant Alm.	R - α	Decl.
moon 20 ^h	1 ^h 46 ^m 47.33 ^s	+ 12 ^o 37' 17.9"
moon 21 ^h 19.517		13.837
" 16.554	- 32.31	- 3 49.1
Tabular place	1 46 15.02	+ 12 33 28.8

Moon's age	19 days
" parallax	56' 02.7
" semidiam	15' 17.9
R	9 17.9
Augmentation	+ 13.0
Iradiation (3)	- 0.7
R	9 30.2
R	1.9940
α = 0	(1 + α) R
	R ²
	3.9760

1980 Times etc.

Epoch Time 1912 Aug 31	1	32	-	1	44	
" Moon	1	38	191	-	1	38 19.4
clockwise	1	016				
H Sid T	1	39	2085			
H long	4	44	31.05			
G Sid T	6	23	5190			
Sid T in km	10	37	1073			
Interval	19	46	4117			
Rotation		3	1441			
G in T	19	43	2676	G-X	-	0 07

From Kant Allen.	R-G	black
moon 20"	1 46 47.33	+12 37 17.9
moon 1" 1.9548		13 37.7
-16.554	-3231	- 3 49.1
Tabular place	1 46 1502	+12 33 28.8

Moon's age	19 days
parallax	56' 02.7
semidiam	15' 17.9
R	9 17.9
Amplitude	+13.0
Inachalm (3)	- 0.7
R	9302
R	1.9940
(1+a) R	
R	3.9760

934 = 13.5
912 = 13.0

Plate Constants

5-

x	y	R.A.	Decl.
10.4550	23.4216	1 42 54	+12 45 05
23.3035	9.6434	49 43	10 58 10
23.9207	27.8240	50 03	13 19 29
3 57.68	60.89	141 100	35 122 44
19.23	20.30	1 47 33	+12 20 55
-18.	-22	-38	+13 10
1.23	1.70		
31	465		
38 ^s	790"		
		$A = 1^h 46^m 55^s$	+12 34 05

$$A = 1^h 46^m 55^s$$

$$D = +12^\circ 34' 05''$$

$$\begin{aligned}
 x - \bar{x} &= -16.04 & +18.7 \\
 +188 &- 875 = -187 & = 0 \\
 -33 &- 154 = -187 & = 0 \\
 +259 &- 445 = -186 & = +1 \\
 16.8510 &- 292 = & = 16.8406
 \end{aligned}$$

$$\begin{aligned}
 y - \bar{y} &+ 13.32 & +24 & -70 \\
 -74 &+ 139 = +65 & +5 = +70 & = 0 \\
 -242 &+ 310 = +68 & +2 = +70 & = 0 \\
 -254 &+ 318 = +64 & +6 = +70 & = 0 \\
 18.2615 &+ 224 = & +4 & = 18.2773
 \end{aligned}$$

Tables	$a = -0.8$	$e = -2.0$	$a - e = +1.2$	$\Delta a = 0.0$
Obs	$a = 0.0$	$e = -0.2$	$a - e = +0.2$	+2.7

Plate Constant

x	y	RA	$Decl.$
10.4550	23.4216	1 42 54	+12 45 05
23.3035	9.6434	49 43	10 58 10
23.9207	27.8240	50 03	13 19 29
3 57.68	60.89	141 100	35 122 44
19.23	20.30	1 47 33	+12 20 55
-18	-22	-38	+13 10
1.23	1.70		
31	46		
38	790		

$$A = 1^h 46^m 55^s \quad +12^{\circ} 34' 05''$$

$$A = 1^h 46^m 55^s$$

$$D = +12^{\circ} 34' 05''$$

$$\begin{aligned}
 x - 3 &= -16.04 & +187 \\
 +188 &= 375 & = -187 & = 0 \\
 -33 &= -154 & = -187 & = 0 \\
 +259 &= 445 & = -186 & = -1 \\
 16.8510 &= 292 & & = 16.8405
 \end{aligned}$$

$$\begin{aligned}
 y - 7 &+ 13.3x & + 24 & - 70 \\
 -74 &+ 139 & + 65 & - 5 & + 70 & = 0 \\
 -242 &+ 310 & + 68 & + 2 & + 70 & = 0 \\
 -254 &+ 318 & + 64 & + 8 & + 70 & = 0 \\
 182615 &+ 224 & + 4 & & & = 182793
 \end{aligned}$$

$$\begin{array}{llll}
 \text{Tables} & a = -0.8 & e = -2.0 & a - e = +1.2 \\
 \text{Obs} & a = 0.0 & e = -0.2 & a - e = +0.2
 \end{array}$$

1980

Standard Coordinates

6.

Cape W. 254 mag 8.6

Cape W. 274 mag 8.0

Cape W. 277 mag 8.1

C	1	42	15.38	* 1	49	04.75	1	49	24.76
L			46			7.3			78
E			38			7.5			78
mean	1	42	15.41	1	49	04.74	1	49	24.77
prec			+38.44			+38.29			+38.61
X	1	42	53.85	1	49	43.03	1	50	03.38
A	1	46	55	1	46	55	1	46	55
X-A	-	4	01.15	+	2	48.03	+	3	08.38
tan(X-A)			-241.14			+168.03			+188.37
log...			2.38227m			2.22539			2.27501
cos			9.98916			9.99200			9.98815
Σ			0.87867m			0.72463			0.77040
Σ			-7.5626			+5.3043			+5.8939
Σ			-12			+25			+9
Σ			10.4362			23.3068			23.8948
Σ			10.4550			23.3035			23.9207
Σ-Σ			+188			-33			+259

C	+12°	41'	28".4	+10°	54'	37".1	+13°	15'	56".2
L			27.9			36.5			55.4
E			27.4			37.0			55.6
mean	+12	41	27.9	+10	54	36.4	+13	15	55.7
prec		+3	36.9		+3	33.6		+3	33.5
δ	+12	45	04.8	+10	58	10.5	+13	19	29.2
D	+12	34	05	+12	34	05	+12	34	05
δ-D		+10	59.8	-1	35	54.5		+45	24.2
tan(δ-D)			+659.8			-5756.0			+2724.4
log...			2.81941			3.76012m			3.43527
cos			0.15056			1.09127m			0.76642
tan			9.3547			9.2874			9.3745
Σ			17.573			144.93			154.08
Σ			81.654			7.7901			7.9687
Σ			+14144			-12.3386			+58401
Σ			+146			+62			+93
Σ			23.4290			9.6676			27.8494
Σ			23.4216			9.6434			27.8240
Σ-Σ			-74			-242			-254

1980.

Standard

Circumstances

Cape W. 254 mg 8.6

Cape W. 274 mg 8.0

Cape W. 277 mg 8.1

C	1	42	15.38	+ 1	49	04.75	1	49	24.76
L			46			7.3			78
E			38			7.5			78
mean	1	42	15.41	1	49	04.74	1	49	24.77
Proc			+ 38.44			+ 38.29			+ 38.61
X	1	42	53.85	1	49	43.03	1	50	03.38
A	1	46	55	1	46	55	1	46	55
X-A	- 4	0	1.15	+ 2	48.03		+ 3	08.38	
m (d H)			- 24.14		+ 168.03			+ 188.37	
log			2.38227		2.22539			2.27150	
cos			998916		999200			998815	
3.			0.87867		0.72463			0.77040	
3.			- 7.5626		+ 5.3043			+ 5.8939	
3.			12		+ 25			+ 9	
3.			10.4362		23.3068			23.8948	
3.			10.4550		23.3035			23.9207	
3.			+ 188		- 33			+ 259	

C	+ 12	41	28.4	+ 10	54	37.1	+ 13	15	56.2
L			27.9			36.5			55.4
E			27.4			37.0			55.6
mean	+ 12	41	27.9	+ 10	54	36.4	+ 13	15	55.7
Proc		+ 3	36.9		+ 3	38.6		+ 3	33.5
X	+ 12	45	04.8	+ 10	58	10.5	+ 13	19	29.2
D	+ 12	34	05	+ 12	34	05	+ 12	34	05
S-H		+ 10	59.8	- 1	35	54.5		+ 45	24.2
tan (S-H)			+ 659.8		- 575.60			+ 272.44	
log			2.81941		3.76012			3.43527	
3.			0.15056		1.09127			0.76642	
tan S			9.3547		9.2874			9.3745	
3.			17.573		14.493			15.408	
3.			81.654		77.901			79.687	
3.			+ 141.44		- 12.3386			+ 5.8401	
3.			+ 146		+ 62			+ 93	
3.			23.4290		9.6676			27.8494	
3.			23.4216		9.6434			27.8240	
3.			- 74		- 242			- 259	

$$\Delta x = 0$$

$$\Delta y = +1 - (y - y_0)$$

pt.	mv. c	residual
1	144.7	+33
2	129.1	+136
3	97.5	-22
$\frac{1}{4} \text{ m.}$ 4	90.0	-316
5	68.2	+98
6	35.3	-15
7	4.4	+12
8	349.0	+7

1980 *Lyman's Center*

	x	$x - x_0$	$(x - x_0)^2$	$(x - x_0)^2 + (y - y_0)^2$	$0 - c$
1	18.0000	+1.1554	1.3349	3.9921	+1.61
2	18.3996	+1.5550	2.4180	4.0081	+3.21
3	18.8273	+1.9827	3.9311	3.9992	+2.32
4	18.8372	+1.9926	3.9704	3.9704	-5.6 ($\frac{1}{4}$ wt)
5	18.7060	+1.8614	3.4648	4.0112	+3.52
6	18.0000	+1.1554	1.3349	3.9921	+1.61
7	17.0000	+0.1554	0.0241	3.9822	+6.2
8	16.4636	-0.3810	0.1452	3.9746	-1.4

Comp $R^2 = 3.9760$

	y	$y - y_0$	Δy	$(y - y_0)^2$
1	16.6310	-1.6299	-2	2.6572
2	17.0000	-1.2609	-1	1.5901
3	18.0000	-0.2609	-0	0.0681
4	18.2609	0.0000	0	0.0000
5	19.0000	+0.7391	+1	0.5464
6	19.8908	+1.6299	+2	2.6572
7	20.2502	+1.9893	+2	3.9581
8	20.2176	+1.9567	+2	3.8294

Upper Center

$$x = 18.0 \quad y = 16.6310$$

$$19.8908$$

$$36.5218$$

$$y_0 = 18.2609$$

$$y = \text{max} = 20.2531$$

$$R = 1.9926$$

$$x = \text{max} = 18.8372$$

$$x_0 = 16.8446$$

$$\text{Center } \begin{cases} x = 16.8446 \\ y = 18.2609 \end{cases}$$

1980

Luvon's Center

	x	y	$x - x_0$	$(x - x_0)^2$	$(x - x_0)^2 + (y - y_0)^2$	$y - y_0$
1	18.0000	0 + 1.1554	1.3349	3.9921	+ 1.61	
2	18.3996	+ 1.5550	2.4180	4.0081	+ 3.21	
3	18.8273	+ 1.9827	3.9311	3.9992	+ 2.32	
4	18.8372	+ 1.9926	3.9704	3.9704	- 5.6 $\frac{1}{4}w$	
5	18.7060	+ 1.8614	3.4648	4.0112	+ 3.52	
6	18.0000	+ 1.1554	1.3349	3.9921	+ 1.61	
7	17.0000	+ 0.1554	0.0241	3.9822	+ .62	
8	16.4636	- 0.3810	0.1412	3.9746	- 1.4	

Comp R^2 3.9760

Avg 156

	x	y	$y - Y_0$	Δy	$(y - Y_0)^2$
1	16.6310	-1.6299	-2	2.6572	
2	17.0000	-1.2609	-1	1.5901	
3	18.0000	-0.2609	-0	0.0681	
4	18.2609	0.0000	0	0.0000	
5	19.0000	+0.7391	+1	0.5464	
6	19.8908	+1.6299	+2	2.6572	
7	20.2502	+1.9893	+2	3.9581	
8	20.2176	+1.9567	+2	3.8294	

Approx. Center

$$x = 18.0 \quad y = 16.6310$$

$$19.8908$$

$$36.5218$$

$$y_0 = 18.2609$$

$$y = \max = 20.2531$$

$$R = 1.9926$$

$$x = \max = 18.8372$$

$$x_0 = 16.8446$$

$$\text{Center} \begin{cases} x = 16.8446 \\ y_0 = 18.2609 \end{cases}$$

formation of normals.

ab

an

bn

1	- 1.89	+ 187.0	- 262.8
2	- 0.59	+ 125.2	- 101.2
3	- 0.52	+ 460.0	- 60.4
4	+ 0.00	- 7.7	- 0.0
5	+ 1.38	+ 655.0	+ 260.5
6	+ 1.49	+ 187.0	+ 262.8
7	+ 0.32	+ 9.9	+ 123.0
8	- 2.74	+ 5.3	- 27.4
	- 0.15	+ 1621.7	+ 194.5
	- 0.59	+ 125.2	- 101.2
	- 0.74	+ 1746.9	+ 93.3

giving (2) full wt.

1980

Woods Center

8

Conditional Equations

	a	b	0		c	0-c
1	+1.16	-1.63	= +1.61	+1.52	-2.4	= +1.28 +3.3
2	+1.56	-1.26	= +3.21	+2.04	-1.9	= +1.85 +1.36
3	+1.98	-0.26	= +2.32	+2.58	-4	= +2.54 -2.2
4	+1.99	+0.00	= -5.6	+2.60	+0	= +2.60 -3.16
5	+1.86	+0.74	= +3.52	+2.43	+1.1	= +1.54 +9.8
6	+1.16	+1.63	= +1.61	+1.52	+2.4	= +1.76 -1.5
7	+0.16	+1.99	= +6.2	+2.1	+2.9	= +5.0 +1.2
8	-0.38	+1.96	= -1.4	-5.0	+2.9	= -2.1 +7

Average = 80.

Normal Equations

$$\begin{aligned}
 +12.44 - 0.15 &= +16.22 \\
 -0.15 + 14.51 &= +1.94 \\
 +0.15 - 0.00 &= +2.0 \\
 +14.51 &= +2.14 \\
 +12.44 &= +16.22 + 2 = +16.24
 \end{aligned}$$

giving 2 full wt.

$$\begin{aligned}
 +12.90 - 0.74 &= +17.47 \\
 -0.74 + 15.31 &= +9.3
 \end{aligned}$$

$$\begin{aligned}
 +0.74 - 0.04 &= +1.00 \\
 +15.27 &= +1.93
 \end{aligned}$$

$$+12.90 = +17.47 + 9 = +17.56$$

$$b = +14.7$$

$$a = +130.5$$

$$t = +12.8$$

$$a = +130.66$$

1980

huonis Center

8

Conditional Equations.

	a	b	c	d	e	f	g	h
--	---	---	---	---	---	---	---	---

1	+1.16	-1.63	+1.61	+1.52	-2.4	+1.28	+3.3	
2	+1.56	-1.26	+3.21	+2.04	-1.9	+1.45	+1.36	
3	+1.98	-0.26	+2.32	+2.58	-4	+2.54	-2.2	
4	+1.99	+0.00	-5.6	+2.60	-0	+2.60	-3.16	
5	+1.86	+0.74	+3.52	+2.43	-1.1	+2.15	+9.8	
6	+1.16	+1.63	+1.61	+1.52	-2.4	+1.76	-1.5	
7	+0.16	+1.99	+6.2	+2.1	-2.9	+5.0	+1.2	
8	-0.38	+1.96	-1.4	-5.0	-2.9	-2.1	+7	

Average = 80.

Normal Equations.

~~$$\begin{aligned}
 +1.244 - 0.15 &= +1.622 \\
 -0.15 + 1.451 &= +1.94 \\
 +0.15 - 0.00 &= +2.0 \\
 +1.451 &= +2.14 \\
 +1.244 + 1.622 + 2 &= +1.624
 \end{aligned}$$~~

~~$$b = +1.47$$~~

~~$$a = +130.5$$~~

giving 2 full set

$$\begin{aligned}
 +1.290 - 0.74 &= +1.747 \\
 -0.74 + 1.531 &= +9.3
 \end{aligned}$$

$$\begin{aligned}
 +0.74 - 0.04 &= +1.015 \\
 +1.527 &= +1.88
 \end{aligned}$$

$$h = +12.6$$

$$+1.395 = +1.747 + 9 = +1.756$$

$$c = +13.066$$

Red ad. L. aph.

$$\begin{aligned}
 +\lambda &= 9 \quad 19 = 139^{\circ} 95' \\
 H &= 7 \quad 33 \\
 \lambda &= 1 \quad 46 \\
 G &= 21 \quad 28 \\
 +Q &= 23 \quad 14 \quad 348^{\circ} 30'
 \end{aligned}$$

$$S = T12 \quad 0.5$$

$$\begin{aligned}
 \log i &= 0.8793 \\
 \log s &= 9.9903 \\
 \log &= 0.8696
 \end{aligned}$$

$$\begin{aligned}
 \log \cos(\delta + \lambda) &= 9.9912 \\
 \log &= 1.1794 \\
 \log \cos(\delta + \lambda) &= 9.2997 \\
 \log s &= 9.3306 \\
 \log &= 8.8239
 \end{aligned}$$

$$\begin{aligned}
 \log \sin \delta &= 9.3208 \\
 \log \cos(\delta) &= 9.8827 \\
 \log &= 1.2792 \\
 \sin(\delta + \lambda) &= 9.8103 \\
 \log s &= 0.0097 \\
 \log &= 8.8239
 \end{aligned}$$

$$\begin{aligned}
 \log &= 1.1706 \\
 \log &= 8.6336
 \end{aligned}$$

$$\begin{aligned}
 \log 'G' &= 0.4827 \\
 \log &= 9.9231
 \end{aligned}$$

$$\begin{aligned}
 f &= 1.84 \\
 + & 0.04 \\
 0 &= 0.84 \\
 + & 2.64
 \end{aligned}$$

$$\begin{aligned}
 G &= +14.81 \\
 1 &= -3.04 \\
 + & 7.91 \\
 + & 19.18
 \end{aligned}$$

1980 Moon's Mean Position (1912.0)

$$\begin{array}{rcl}
 X_0 = 16.8446 & Y_0 = 18.2609 & \\
 \frac{1}{2}a = \quad \quad + 6.5 & \frac{1}{2}b = \quad \quad + 6 & \\
 \hline
 16.8511 & 18.2615 &
 \end{array}$$

From Plate Constants $X = 16.8406$ $Y_0 = 18.2773$

$$\begin{array}{rcl}
 \bar{z} = -1.1594 & & \\
 \log \bar{z} = 0.06423 & & \\
 \cos \bar{z} = 999027 & & \\
 \dots \text{const} = 8.50724 & & \\
 \dots (d-A) = 1.56672 & & \\
 X-A = \quad \quad 36.88 & & \\
 A = 1 \quad 46 \quad 55 & & \\
 X_0 = 1^{\text{h}} 46^{\text{m}} 18.72 & &
 \end{array}$$

$$\begin{array}{rcl}
 \text{Read off app.} & + & 2.64 \\
 d' = 1 \quad 46 \quad 20.76 & &
 \end{array}$$

$$\begin{array}{rcl}
 \eta = -3.7227 & & \\
 \log \tan S = 7.0534 & & \\
 \log \tan S = 9.3336 & & \\
 \dots \eta_2 = 0.1285 & & \\
 \dots \eta_1 = 6.5155 & & \\
 \eta_1 = \quad \quad + 3 & & \\
 \eta_0 = -3.7230 & & \\
 \log \eta_0 = 0.57089 & & \\
 \dots \text{const} = 7.3311 & &
 \end{array}$$

$$\begin{array}{rcl}
 (d-b) = 3.23974 & & \\
 S-D = \quad \quad - \quad 28 \quad 56.8 & & \\
 D = +12 \quad 34 \quad 05 & & \\
 S_0 = +12^{\circ} 05' 08.2 & & \\
 \text{Read off app.} & + & 19.2 \\
 S' = +12 \quad 05 \quad 27.4 & &
 \end{array}$$

Red. ad. 2. aph.

$$H + \alpha_0 = 9 \quad 19 = 139^\circ 45'$$

$$H = 7 \quad 33$$

$$\alpha_0 = 1 \quad 46$$

$$G = 21 \quad 28$$

$$G + \alpha_1 = 23 \quad 14 = 348^\circ 30'$$

$$S_0 = +12 \quad 05$$

$$\log i = 0.8793$$

$$\therefore \cos \delta = 9.9903$$

$$\therefore (i) = 0.8696$$

$$\log \cos(H + \alpha_0) = 9.9912$$

$$\therefore \sin(H + \alpha_0) = 1.1794$$

$$\therefore \sin(G + \alpha_0) = 9.2997$$

$$\therefore \tan \delta = 9.3306$$

$$\therefore \frac{1}{\tan \delta} = 8.8239$$

$$\log \sin S_0 = 9.3208$$

$$\therefore \cos(H + \alpha_0) = 9.8827$$

$$\therefore \sin(H + \alpha_0) = 1.2792$$

$$\therefore \sin(G + \alpha_0) = 9.8103$$

$$\therefore \sec \delta = 0.0097$$

$$\therefore \frac{1}{\tan \delta} = 8.8239$$

$$\log(S') = 1.1706$$

$$\therefore (S) = 86336$$

$$\log(h') = 0.4827$$

$$\therefore (h) = 9.9231$$

$$\begin{array}{r} f \\ (S) \\ (h) \end{array} \begin{array}{r} + 1.84 \\ + 0.04 \\ + 0.84 \\ \hline + 2.64 \end{array}$$

$$\begin{array}{r} (S') \\ (h') \\ (i) \end{array} \begin{array}{r} + 14.81 \\ - 3.04 \\ + 7.41 \\ \hline + 19.18 \end{array}$$

1980 mean lunar Position (1912.0)

$$\begin{array}{r}
 X_0 = 168446 \\
 \hline
 + 64 \\
 \hline
 168510
 \end{array}
 \qquad
 \begin{array}{r}
 Y_0 = 182609 \\
 \hline
 + 6 \\
 \hline
 182615
 \end{array}$$

From Plate Constants $X = 168405$ $Y = 182773$

$$\begin{array}{r}
 z = -11595 \\
 \log z = 0.06427 \\
 \cos z = 999027 \\
 \sin z = 850724
 \end{array}$$

$$(x-A) = 156676$$

$$x-A = 36.88$$

$$A = 14655$$

$$x_0 = 1461872$$

$$\text{Reduction} = 2.64$$

$$x' = 1462076$$

$$y = -37227$$

$$\log |y| = 9.3336$$

$$\cos y = 0.1267$$

$$\sin y = 65137$$

$$y_1 = +3$$

$$y_2 = -37230$$

$$\log y_2 = 0.57089$$

$$\cos y_2 = 733115$$

$$(y-B) = 323974$$

$$y-B = -28568$$

$$B = +123405$$

$$S = +12^{\circ} 05' 08.2''$$

$$\text{Reduction} = 192$$

$$S = +12^{\circ} 05' 29.4''$$

1980. Lunar Parallax

$$\begin{array}{r}
 \alpha' = 1 \quad 46 \quad 20.76^{\circ} \checkmark \\
 \delta = 1 \quad 39 \quad 20.85^{\circ} \checkmark \\
 0 \quad - \quad 7 \quad 00.00^{\circ} \checkmark \\
 - \quad - \quad 1^{\circ} \quad 45' \checkmark
 \end{array}$$

$$\begin{array}{r}
 - \quad 1 \\
 - \quad 1 \quad 44
 \end{array}$$

$$\begin{array}{r}
 9.95727^{\circ} \\
 0.00000 \\
 0.00020^{\circ}
 \end{array}$$

$$\text{Longitude } 9.95747$$

$$f = 42 \quad 11 \quad 57.7^{\circ} \checkmark$$

$$+ 12 \quad 05 \quad 29.4^{\circ} \checkmark$$

$$30 \quad 06 \quad 30.3^{\circ} \checkmark$$

$$\begin{array}{r}
 9.82640^{\circ} \checkmark \\
 8.21224^{\circ} \checkmark \\
 9.70039^{\circ} \checkmark \\
 0.17281^{\circ} \checkmark
 \end{array}$$

$$\sin(\delta - \delta') \quad 7.91184^{\circ} \checkmark$$

$$S - S' = + 28 \quad 03.7^{\circ} \checkmark$$

$$S' = + 12 \quad 33 \quad 31.1^{\circ} \checkmark$$

$$\text{Am Eph } \delta = + 12 \quad 33 \quad 28.8^{\circ} \checkmark$$

$$0 - c \quad + \quad 2.3^{\circ} \checkmark$$

$$\delta' = + 12^{\circ} \quad 05' \quad 27.4^{\circ} \checkmark$$

$$\mu = 56' \quad 02.7^{\circ} \checkmark$$

$$\begin{array}{r}
 9.86913^{\circ} \checkmark \\
 8.21224^{\circ} \checkmark \\
 8.48485^{\circ} \checkmark \\
 0.01051^{\circ} \checkmark
 \end{array}$$

$$\sin(\alpha - \alpha') = 6.57673^{\circ} \checkmark$$

$$\alpha - \alpha' = - 1' \quad 17.83^{\circ} \checkmark$$

$$= - 5.19^{\circ} \checkmark$$

$$\alpha = 1 \quad 46 \quad 15.57^{\circ} \checkmark$$

$$\alpha = 1 \quad 46 \quad 15.02^{\circ} \checkmark$$

$$+ 0.55^{\circ} \checkmark$$

1980 ~~Linear~~ Parabolic

$$\alpha' = 1 \quad 96 \quad 20.76$$

$$\delta = 1 \quad 39 \quad 20.45$$

$$0 \quad - \quad 7 \quad 00.00$$

$$- 1^{\circ} 45'$$

$$- 1$$

$$- 1 \quad 44$$

$$9.95727$$

$$0.00000$$

$$0.00020$$

$$\text{log } 9.95747$$

$$f \quad 42 \quad 11 \quad 57.7$$

$$12 \quad 05 \quad 28.4$$

$$30 \quad 06 \quad 29.3$$

$$9.82640$$

$$8.21224$$

$$9.70039$$

$$0.17281$$

$$m(\alpha-\delta) \quad 7.91184$$

$$S-S' = \quad + 28 \quad 03.7$$

$$S' = +12 \quad 33 \quad 32.1$$

$$\text{Ann Eph } S = +12 \quad 33 \quad 28.8$$

$$0 = \quad + \quad 2.3$$

$$\delta' = +12^{\circ} 05' 27.4$$

$$\alpha = 56' 02.7$$

$$9.86913$$

$$8.21224$$

$$8.48485$$

$$0.01049$$

$$\text{Sum } (\alpha-\delta) \quad 6.57671$$

$$\alpha - \alpha' = 1 \quad 17.43$$

$$= - \quad 5.19$$

$$\alpha = 1 \quad 46 \quad 15.57$$

$$\alpha = 1 \quad 46 \quad 15.02$$

$$+ 0.55$$

1

1

10.

22.

.

2

23

9.1

3

23

2

1981

Star measures

1913 Dec. 5.

11

	α	δ
1	19745-	17799
10.1	1237098	1516069
22.7	76	60
	30	80
	<u>22.7359</u>	<u>.7370</u>

2	14097	1166261-
9.0	13983	64
	8987	11568

<u>9.0111</u>	<u>.0096</u>
---------------	--------------

3	16866	17081
23.6	1499188	896260
27.2	90	61
	56	87
	<u>27.1874</u>	<u>.1875</u>

grade 2.

	α	δ
1	15358	17422
10.1	209193	15678
22.7	99	7171
	48	98
	<u>10.1744</u>	<u>.1745</u>

2	12545-49	11309
9.0	3547	10545-46
	11798	~~2745-~~

<u>23.0746</u>	<u>.0758</u>
----------------	--------------

3	17339	18196
23.6	13500	1209000
27.2	0097	10
	20	78
	<u>23.6167</u>	<u>.6178</u>

1981

Star measures

1913 Dec 5.

11

	α	δ
1	19745	17799
10.1	12370	15160
227	76	60
	30	80
	<u>227359</u>	<u>7370</u>

3	14097	11662
9.0	13983	64
	8987	11568

<u>9.0111</u>	<u>10096</u>
---------------	--------------

3	16866	17081
236	14991	8962
272	90	61
	56	87
	<u>271874</u>	<u>1875</u>

Grade 2.

	α	δ
1	15358	17422
	709193	15678
	99	7171
	48	98
	<u>101744</u>	<u>1745</u>

12545	11309
3147	10545
11798	2745

<u>230746</u>	<u>0718</u>
---------------	-------------

17339	18196
13500	1201000
0097	10
20	78
<u>236167</u>	<u>6178</u>

1
18.
16.

2
18.
16.

3
18.
17.

4
19.
17.5

5
19.
18.
17.
16.

6
18.
19.

1981

lunar measures.

	α	δ	α	δ
1	15552	15271		
8.0	13241	758570		
16.4	4040	81		
	32	59		
	<u>162308</u>	<u>.2317</u>		

possibly on
termination

2 scratch.

8.5	16100	15286
6.5	10150	11215
	45	19
	82	76
	<u>16.5940</u>	<u>.5939</u>

15952	16267
11070	11139
8980	2733
46	50
<u>18.5133</u>	<u>.5125</u>

3
18.7
17.0

14945	15278
131918	708574
82	084
37	61
<u>18.8243</u>	<u>8252</u>

4 scratch.

19.0	19691	20000
17.5	14120	155575
	19	60
	20	78
	61	
	<u>17.5555</u>	<u>.5567</u>

13540	11860
3040	113334
13030	40
<u>19.0507</u>	<u>.0522</u>

5
19.1
18.0
mean
86

12990	14052
8180	1306052
12005	3544

<u>19.0979</u>	<u>.1004</u>
----------------	--------------

18.3	10
18.8	1677180
19.0	7980
	00
	<u>18.8469</u>

17812
935055
5255
06
<u>.8455</u>

1981

Moon measures

1 15552
 180 13291 40
 119 40
 32
162308

15271
 715570
 81
 59
2317

possibly on
termination

2 scratch

185 16100
 165 10150 53
 45
 82
165940

15286
 1121529
 19
 76
15939

15952
 11070 89
 89 50
 46
185133

16267
 11139
 27 33
 50
5125

3

187
 7.0

14945
 1319185
 82
 37
188243

15278
 701574
 084
 61
8252

4 scratch

14.4 19691
 75 1412019
 20
 61
175555

20000
 155571
 60
 78
5567

13540
 30 40
 13030
190507

11860
 1133341
 40
0522

5

19.1
 180

12990
 81 50
 12005

14052
 1306052
 3544

190979

1004

6 18310
 18.8 1677150
 190 79 50
 00
188469

17812
 935055
 52 55
 06
8455

7
18
10

8
1-
2
M

9
10
10

1981 moon measures.

	α	δ	α	δ	α	δ
7	17380		20111			
18.0	932115		1809510			
19.7	20		02			
	65		9096			
	<u>198049</u>		<u>7994</u>			
8						
17.0	11656		982830			
20.0	1158078		23			
max	61		9748			
in						
8	<u>200083</u>		<u>0079</u>			

9	Scratch				
16.6	1216952	9955	17460	15429	
19.9	4163	944948	13671	919898	
	11661	40	7976	91	
			39	11	
	<u>199504</u>	<u>9491</u>	<u>166224</u>	<u>6220</u>	

1981 moon measures

	d	u	v	d	u	v
7	17380		20111			
150	932115		1809510			
197	20		02			
	65		9096			
	<u>198049</u>		<u>7994</u>			
8						
170	11656		982830			
200	1155078		23			
max	61		9748			
u						
8	<u>200083</u>		<u>0079</u>			

9	Scratch				
66	1216952	9955	17460	11429	
199	4163	944948	1367176	919898	
	11661	40	7976	9198	
			39	11	
	<u>199504</u>	<u>9491</u>	<u>166224</u>	<u>6220</u>	

1981

Times etc.

Exp to star	1912 Aug 31	1 ^h 46 ^m		- 1 ^h 58 ^m
known		1 52	02.0	- 1 52 02.4
clockwork		1	01.6	
H Sid T.		1 53	03.8	
H hour		4 44	31.0	
Sid T.		6 37	34.8	
Sid T. known		10 37	10.7	
Interval		20 00	24.1	
Reduction		3	1666	
G.M.T.		19 57	0746	- X = + 0 ^h 06 ^m

from Kant. Alm.		R.A.		Decl.
known 20 ^h	1 ^h 46 ^m	47.33		+ 12° 37' 17.9"
known with 1.9523			13.832	
" -2.8757		5.61		- 39.8
Tabular place	1 46	41.72		+ 12 36 38.1

Moon's age 19 days.

934 = 131.5

918 = 136

" Parallax

" Semidiameter

R

Augmentation

Irradiation (2)

R

R

a = -3.4

(1+a) R

R²

56' 03.0"

15 18.0"

9 18.0"

+ 13.0"

- 0.5"

930.5"

19946"

19939"

39756"

1981

Times etc.

Exp. to star	1912 Aug 31	1" 46"	-1" 58"
" known		1 52	02.0 - 1 52 02.4
clockwork		1	01.6
H. dist. T.		1 53	03.8
H. long		4 44	31.05
⊙ dist. T.		6 37	34.85
Sid. to known		10 37	10.73
Induced		20 00	24.12
Reduction		3	16.66
G. M. T.		19 57	07.46 0-X + 0 ^h 06 ^m

from bank. Allen		R.A.	Decl.
known 20"	1" 46"	47.33	+12° 37' 17.9
known 1" 1.9523	-		13.832
" -2.8757	-	56.1	-39.8
Tabular place	1 46	41.72	+12 36 38.1

known age 19 days

	" parallax	56' 03.0
	Semidiam.	15 18.0
939 = 13.5"	R	918.0
918 = 13.6	Amplitude	+13.0
	Parallax (2)	- 0.5"
	R	930.5
	R	199.46
a = 3.4	(1+a) R	199.39
	R ²	397.56

1981

Plate Constants

	1	2	3
x	10.1744	23.0752	23.6172
y	10.4362	23.3068	23.8948
$x-3$	-2618	-2316	-2776
y	22.7364	9.0104	27.1874
y	23.4290	9.6676	27.8494
$y-\eta$	-6926	-6572	-6620

$$\begin{array}{rclcl}
 x-3 & +25.24 & & +3.4x & +2011 \\
 -2618 + 573 & = & -2045 & +35 & = -2010 & = +1 \\
 -2316 + 227 & = & -2089 & +78 & = -2011 & = 0 \\
 -2776 + 685 & = & -2091 & +80 & = -2011 & = 0 \\
 17.1106 & +454 & & +58 & & = 17.3629
 \end{array}$$

$$\begin{array}{rclcl}
 y-\eta & -242 & & +3.3y & +7096 \\
 -6926 - 244 & = & -7170 & +75 & = -7095 & = +1 \\
 -6572 - 554 & = & -7126 & +30 & = -7096 & = 0 \\
 -6620 - 567 & = & -7187 & +90 & = -7097 & = -1 \\
 18.0162 & -411 & & +59 & & = 18.6906
 \end{array}$$

$$\begin{array}{llll}
 \text{Tables} & a = -0.8 & e = -2.0 & a - e = +1.2 & b + a = 0.0 \\
 \text{Obs} & a = -3.4 & e = -3.3 & a - e = -0.1 & b + a = -1.2
 \end{array}$$

1981 Plate constants

	1	2	3
γ	10.1744	23.0752	23.6172
δ	10.4362	23.3068	23.8948
$\gamma - \delta$	-2618	-2316	-2776
η	22.7364	9.0104	27.1874
γ	23.4290	9.6676	27.8494
$\eta - \gamma$	-6926	-6572	-6620

$$\begin{array}{rcl}
 \gamma - \delta & + 2524 & + 342 & + 2011 \\
 -2618 + 573 & = -2045 & + 35 & = -2010 & = +1 \\
 -2316 + 227 & = -2089 & + 78 & = -2011 & = 0 \\
 -2776 + 685 & = -2091 & + 80 & = -2011 & = 0 \\
 17.1106 + 454 & & + 58 & & = 17.3629
 \end{array}$$

$$\begin{array}{rcl}
 \eta - \gamma & - 242 & + 334 & + 7096 \\
 -6926 - 244 & = -7170 & + 75 & = -7095 & = +1 \\
 -6572 - 554 & = -7126 & + 30 & = -7096 & = 0 \\
 -6620 - 567 & = -7187 & + 90 & = -7097 & = -1 \\
 18.0162 - 411 & & + 59 & & = 18.6906
 \end{array}$$

$$\begin{array}{rcl}
 \text{Tables } a = -0.8 & e = -2.0 & a - e = +1.2 & b + a = 0.0 \\
 \text{Obs } a = -3.4 & e = -3.3 & a - e = -0.1 & b + a = -1.2
 \end{array}$$

ht	rev. L	residual	
1	153.5	+23	+19
2 $\frac{1}{2}$ wt	135.1	+158	+140
3	120.5	-41	-50
4	103.3	+28	+17
5 $\frac{1}{2}$ wt	90.0	-205	-218
6	60.5	+89	+37
7	26.6	+59	+53
8	0.0	-71	-72
9	345.9	+25	+27

1981

huoris Center

	x	$x - x_0$	$(x - x_0)^2$	$(x - x_0)^2 + (y - y_0)^2$	$0 - c$
1	18.0000 + 0.8921	0.7959	3.9846	+ 90	
2	18.5129 + 0.4051	1.9743	3.9995	+ 239 $\frac{1}{2}wt$	
3	18.8248 + 1.7170	2.9481	3.9820	+ 64	
4	19.0514 + 1.9436	3.7775	3.9896	+ 140	
+5	19.0992 + 1.9914	3.9657	3.9660	- 96 $\frac{1}{2}wt$	
6	18.8462 + 1.7384	3.0220	3.9891	+ 135	
7	18.0000 + 0.8921	0.7959	3.9846	+ 90	
8	17.1078 + 0.0000	0.0000	3.9665	- 91	
9	16.6222 - 0.4856	0.2358	3.9735	- 21	

Hic. 1670

Comp R^2 3.9756

	y	$y - Y_0$	Δy	$(y - Y_0)^2$
1	16.2312 - 1.7855	-2	3.1887	
2	16.5940 - 1.4227	-4	2.0252	
3	17.0000 - 1.0167	-1	1.0339	
4	17.5562 - 0.4606	0	0.2121	
5	18.0000 - 0.0167	0	0.0003	
6	19.0000 + 0.9833	+1	0.9671	
7	19.8022 + 1.7855	+2	3.1887	
+8	20.0081 + 1.9914	+2	3.9665	
9	19.9498 + 1.9331	+2	3.7377	

Apfuer. Center

$$x = 18.0 \quad y = 16.2312$$

$$19.8022$$

$$36.0334$$

$$\text{mean } y = 18.0167$$

$$y = \text{max} = 20.0081$$

$$R = 1.9914$$

$$x = \text{max} = 19.0992$$

$$x_0 = 17.1078$$

$$\text{Center } \begin{cases} x_1 = 17.1078 \\ y_0 = 18.0167 \end{cases}$$

1981

Innovis Center

	x	$x - x_0$	$(x - x_0)^2$	$(x - x_0)(y - y_0)$	$y - y_0$
1	180000 + 08921	07959	39846	+ 90	
2	185129 + 04051	19743	39995	+ 239 $\frac{1}{2}$	
3	188248 + 17170	29481	39820	+ 64	
4	190514 + 19436	37775	39896	+ 140	
5	190992 + 19914	39657	39660	- 96 $\frac{1}{2}$	
6	188962 + 17384	30220	39891	+ 135	
7	180000 + 08921	07959	39846	+ 90	
8	171078 + 00000	00000	39665	- 91	
9	166222 - 04856	02358	39735	- 21	

Comp R^2 39756

	y	$y - y_0$	Δy	$(y - y_0)^2$
1	162312 - 17855	-2	31887	
2	165940 - 14227	-4	20252	
3	170000 - 10167	-1	10339	
4	175562 - 04606	0	02121	
5	180000 - 00167	0	00003	
6	190000 + 09833	+1	09671	
7	198022 + 17855	+2	31887	
8	200081 + 19914	+2	39665	
9	199498 + 19331	+2	37377	

Upper Center

 $x = 180$ $y = 162312$ 198022

360334

mean $y = 180167$ y max = 200081 $R = 19914$ x max = 190992 $x_0 = 171078$ Center $\left\{ \begin{array}{l} x = 171078 \\ y = 180167 \end{array} \right.$

Formation of Normals

	ab	an	bn
1	-1.59	+ 80.1	- 161.0
2	-0.86	+ 84.3	- 85.0
3	-1.76	+ 110.0	- 65.2
4	-0.89	+ 271.8	- 64.5
5	-0.01	- 47.8	+ 0.0
6	+1.70	+ 235.0	+ 132.1
7	+1.59	+ 80.1	+ 161.0
8	+0.00	- 0.0	- 181.0
9	-0.94	+ 10.3	- 40.5
	-240	+ 823.8	- 304.1

Residuals

	0		c	0 - c
1	+90	+54 + 17	+ 71	+19
2	+239	+86 + 13	+ 99	+140
3	+64	+105 + 9	+ 114	-50
4	+140	+119 + 4	+ 123	+17
5	-96	+122 + 0	+ 122	-218
6	+135	+107 - 9	+ 98	+37
7	+90	+54 - 17	+ 37	+53
8	-91	+ 0 - 19	- 19	-72
9	-21	-30 - 18	- 48	+27
				+293 - 340
				Average = 70

1981

Inver's Center

Conditional Equations

	a	b	0	c	0-c
1	+0.89	-1.79	= +90	+ 49 + 18 = +67	+23
2	+1.41	-1.42	= +239	+ 67 + 14 = +81	+158
3	+1.72	-1.02	= +64	+ 95 + 10 = +105	-41
4	+1.94	-0.46	= +140	+ 107 + 5 = +112	+28
5	+1.99	-0.02	= -96	+ 109 + 0 = +109	-205
6	+1.74	+0.98	= +135	+ 96 - 10 = +86	+49
7	+0.89	+1.79	= +90	+ 49 - 18 = +31	+59
8	+0.00	+1.99	= -91	+ 0 - 20 = -20	-71
9	-0.49	+1.93	= -21	- 27 - 19 = -46	+25

Average: 73

Normal Equations

$$\begin{aligned}
 +14.55 - 2.40 &= +824 \\
 -2.40 + 17.31 &= -304
 \end{aligned}$$

$$\begin{aligned}
 +2.40 - 0.40 &= +136 \\
 +16.91 &= -168
 \end{aligned}$$

$$+14.55a = +824 - 24 = +800$$

$$b = -9.94$$

$$a = +55.0$$

Corrected solution giving (2) + (5) half wt.

$$\begin{aligned}
 +13.06 - 2.40 &= +824 \\
 -2.40 + 16.80 &= -304
 \end{aligned}$$

$$\begin{aligned}
 +2.40 - 0.44 &= +152 \\
 +16.36 &= -152
 \end{aligned}$$

$$b = -9.3$$

$$+13.06 = +824 - 22 = +802$$

$$a = +61.4$$

Obs measured = 16.7° Average 0-c = -5.2

$$\frac{PC}{n} = 0.24$$

$$\frac{-5.2}{24} = -0.22$$

$$\Delta n = -0.2$$

1981

Inveris Canten

Conditional Equations

	a	b	c	d	e	f	g
1	+0.89	-1.79	=	+90	+49	+18	= +67
2	+1.41	-1.42	=	+239	+67	+14	= +81
3	+1.72	-1.02	=	+64	+95	+10	= +105
4	+1.99	-0.46	=	+140	+107	+5	= +112
5	+1.99	-0.02	=	-96	+109	+0	= +109
6	+1.74	+0.98	=	+135	+96	-10	= +86
7	+0.89	+1.79	=	+90	+49	-18	= +31
8	+0.00	+1.99	=	-91	+0	-20	= -20
9	-0.49	+1.93	=	-21	+27	-19	= -46

Average: 73

Normal Equations

$$+14.55 - 2.40 = +8.24$$

$$-2.40 + 17.31 = -3.04$$

$$+2.40 - 0.40 = +1.36$$

$$+16.91 = -16.8$$

$$+14.552 = +8.24 - 2.4 = +8.00$$

$$b = -9.9$$

$$c = +55.0$$

Corrected Solution giving 121 + (17) half wt.

$$+13.06 - 2.40 = +8.24$$

$$-2.40 + 16.80 = -3.04$$

$$+2.40 - 0.44 = +1.52$$

$$+16.36 = -1.52$$

$$b = -9.3$$

$$+13.06 = +8.24 - 2.2 = +8.02$$

$$c = +61.4$$

Red ad l aph

$$\begin{array}{rcl}
 H + \alpha & 9^h & 20^m = 140^\circ \\
 H & 7 & 33 \\
 \alpha & 1 & 47 \\
 Q & 21 & 28 \\
 G + \alpha & 23 & 15 = 348^\circ 45'
 \end{array}$$

$$\begin{array}{rcl}
 \cos(H + \alpha) & 99916 \\
 \sin & 1.1794 \\
 \sin & 92902m \\
 \tan S & 93324 \\
 \tan & 88239
 \end{array}$$

$$\begin{array}{rcl}
 8' & 11710 \\
 9 & 86259m
 \end{array}$$

$$\begin{array}{rcl}
 h & +184 \\
 c & -0.04 \\
 l & +0.84 \\
 \hline
 & +264
 \end{array}$$

$$S_0 + 12^\circ 0.8'$$

$$\begin{array}{rcl}
 l \cos S & 99902 \\
 i & 0.8797 \\
 (c) & 0.8699
 \end{array}$$

$$\begin{array}{rcl}
 l \sin S & 93226 \\
 \cos(H + \alpha) & 98842m \\
 h & 12791 \\
 \sin & 98081 \\
 \sec S & 0.0098 \\
 \tan & 88239
 \end{array}$$

$$\begin{array}{rcl}
 h' & 04859m \\
 h & 99209
 \end{array}$$

$$\begin{array}{rcl}
 8' & +14.83 \\
 h' & -306 \\
 i & +7.41 \\
 \hline
 & +1918
 \end{array}$$

1981 Moon's Mean Position (1912.0)

$$\begin{array}{r}
 X_0 = 17.1078 \\
 \frac{1}{2}a = +28 \\
 \hline
 17.1106
 \end{array}
 \quad
 \begin{array}{r}
 Y_0 = 18.0167 \\
 \frac{1}{2}b = -5 \\
 \hline
 18.0162
 \end{array}
 \quad
 \begin{array}{r}
 17.1078 \\
 +31 \\
 \hline
 17.1109
 \end{array}$$

$$\text{From Plater Constants } X_0 = 17.8629 \quad Y_0 = 18.6906 \\
 \quad \quad \quad 17.3632$$

$$\begin{array}{r}
 \bar{z} = -0.6371 \\
 \eta = -3.3094
 \end{array}$$

$$\begin{array}{r}
 \log \bar{z} \quad 9.80421 \\
 \log \eta \quad 9.50724 \\
 \log \tan \delta \quad 9.3336 \\
 \log \eta_1 \quad 9.6084 \\
 \log \eta_2 \quad 5.9954
 \end{array}$$

$$\begin{array}{r}
 (d-A) \quad 1.30679 \\
 d-A \quad -20.27 \\
 A \quad 1^h 46^m 55^s
 \end{array}$$

$$\begin{array}{r}
 \alpha_0 \quad 1 \quad 46 \quad 34.73 \\
 (d-D) \quad 3.18861
 \end{array}$$

$$\text{Red ad. C. aff.} \quad +2.64 \quad \delta-D \quad -25 \quad 43.9$$

$$\begin{array}{r}
 \alpha' \quad 1 \quad 46 \quad 37.37 \\
 D \quad +12 \quad 34 \quad 05
 \end{array}$$

$$S = +12 \quad 08 \quad 21.1$$

$$\text{Cor to stand. radius} = -0.03$$

$$\text{Red ad. C. aff.} \quad +1.92$$

$$S' = +12 \quad 08 \quad 40.3$$

$$\text{Cor to stand. r.} = -0.2$$

1981 Unconstrained (Pencil (1912.0))

$$\begin{array}{r}
 X_0 = 17.1078 \\
 \hline
 + 28 \\
 \hline
 17.1106
 \end{array}
 \quad
 \begin{array}{r}
 Y_0 = 18.0167 \\
 \hline
 + 5 \\
 \hline
 18.0162
 \end{array}
 \quad
 \begin{array}{r}
 17.1078 \\
 \hline
 + 31 \\
 \hline
 17.1109
 \end{array}$$

From Plate Constants $X_0 = 17.3629$ $Y_0 = 18.6906$
 17.3632

$$\begin{array}{r}
 Z = -0.6371 \\
 \hline
 -0.6368
 \end{array}
 \quad
 \begin{array}{r}
 \eta = -3.3094
 \end{array}$$

$$\begin{array}{r}
 \log 3 \\
 \hline
 9.80421 \sim 9.80400 \\
 \hline
 \log 5 \\
 \hline
 9.99018 \\
 \hline
 \log 7 \\
 \hline
 8.50724
 \end{array}
 \quad
 \begin{array}{r}
 \log 10 \\
 \hline
 9.33336 \\
 \hline
 9.6084 \\
 \hline
 5.9954 \\
 \hline
 + 1
 \end{array}$$

$$(X - X_0) = 1.30679 \sim (1.30658)$$

$$(Y - Y_0) = -20.27 \sim -20.26$$

$$A = 1^{\circ} 46' 55''$$

$$\begin{array}{r}
 \log \eta_0 = 0.51976 \\
 \hline
 \log \eta = 7.33115
 \end{array}$$

$$X_0 = 1^{\circ} 46' 34.78'' (34.74) \quad (X - X_0) = 3.18861 \sim$$

$$\text{Radial (c. app.)} = +2.64 \quad S - D = -25^{\circ} 43.9'$$

$$X = 1^{\circ} 46' 37.37'' (37.38) \quad D = +12^{\circ} 39' 05''$$

$$S = +12^{\circ} 08' 21.1''$$

$$\text{Constitution radius} = -0.03$$

$$\text{Radial (c. app.)} = +19.2'$$

$$S = +12^{\circ} 08' 40.3''$$

$$\text{Constitution radius} = -0.2$$

1981

Lunar Parallax

19

$$\begin{array}{rcl}
 \alpha & = & 1^h 46^m 37.39^s \\
 \delta & = & 12^\circ 08' 40.3'' \\
 \alpha - \alpha' & = & + 6' 26.4'' \\
 & = & + 1^\circ 36' 36''
 \end{array}$$

$$\begin{array}{rcl}
 \delta' & = & + 12^\circ 08' 40.3'' \\
 \pi & = & 56' 03.0''
 \end{array}$$

$$\begin{array}{r}
 9.95727 \\
 600000 \\
 000017 \\
 \hline
 9.95744
 \end{array}$$

$$\begin{array}{r}
 9.86913 \\
 8.21228 \\
 8.44865 \\
 001061 \\
 \hline
 \sin(\alpha - \alpha') = 6.54067
 \end{array}$$

$$\begin{array}{rcl}
 \alpha - \alpha' & = & + 1' 11.63'' \\
 & = & + 4.78''
 \end{array}$$

$$f = 42 \quad 11 \quad 50.5$$

$$S = +12 \quad 08 \quad 40.3$$

$$f - S = 30 \quad 03 \quad 10.2$$

$$\begin{array}{r}
 9.82640 \\
 8.21228 \\
 9.69967 \\
 0.17283 \\
 \hline
 7.91118
 \end{array}$$

$$\sin(\delta - \delta') = 7.91118$$

$$\delta - \delta' = 28 \quad 01.2$$

$$S = +12 \quad 36 \quad 41.5$$

$$\begin{array}{rcl}
 \alpha & = & 1 \quad 46 \quad 42.16 \\
 & = & 1 \quad 46 \quad 42.15
 \end{array}$$

$$\text{True Eph. } \delta = +12 \quad 36 \quad 38.1$$

$$\alpha = 1 \quad 46 \quad 41.72$$

$$+ 3.4$$

$$+ 0.43$$

$$\text{Corr to standard} = - 0.2$$

$$+ 0.44$$

$$- 0.03$$

$$U - C = + 3.2$$

$$+ 0.41$$

1981

Lunar Parallax

$$\begin{array}{r}
 \alpha = 1^{\circ} 46' 37.38'' \\
 \delta = 1^{\circ} 53' 03.8'' \\
 \alpha - \alpha' = + 6' 26.9'' \\
 = + 1^{\circ} 36' 36.1''
 \end{array}$$

$$\delta' = + 12^{\circ} 08' 40.3''$$

$$\pi = 56' 03.0''$$

$$\begin{array}{r}
 986913 \\
 821228 \\
 844865 \\
 \hline
 001068
 \end{array}$$

$$\sin(\alpha - \alpha') 6.54075$$

$$\begin{array}{r}
 995727 \\
 000000 \\
 000017 \\
 \hline
 995744
 \end{array}$$

$$\alpha - \alpha' = + 1^{\circ} 11.64''$$

$$= + 4.78''$$

$$\gamma = 42^{\circ} 11' 50.5''$$

$$\delta = 12^{\circ} 08' 40.3''$$

$$\delta - \delta' = 30^{\circ} 03' 10.2''$$

$$\begin{array}{r}
 982640 \\
 821228 \\
 969967 \\
 \hline
 017283
 \end{array}$$

$$\sin(\delta - \delta') 7.91118$$

$$\delta - \delta' = 28^{\circ} 01.2''$$

$$\delta = 12^{\circ} 36' 41.5''$$

$$\alpha = 1^{\circ} 46' 42.16''$$

$$\text{Amplitude } \delta = + 12^{\circ} 36' 38.1''$$

$$\alpha = 1^{\circ} 46' 41.72''$$

$$+ 3.4''$$

$$+ 0.93''$$

$$\pi \text{ Star } \sim - 0.2''$$

$$+ 0.44''$$

$$- 0.05''$$

$$U - C = + 3.2''$$

$$+ 0.41''$$

2000

Stars - lucanus

1913 Dec. 6.

	d	"	d	"	d	"	d	"
1	18076	17498	17479	15083				
152	13940	8684	90181	1350701				
315	4540	0809	11	10				
	65	81	58	76				
	<u>314130</u>	<u>4121</u>	<u>151551</u>	<u>1576</u>				
2	15705	19949	17049	15396				
190	13450	1219100	8098	1434132				
103	5049	0500	9990	4032				
	99	66	29					
	<u>102254</u>	<u>2237</u>	<u>191065</u>	<u>1058</u>				
3	9995	713135	14900	14452				
277	9705	30	1212729	681210				
240	0079	6867	23	12				
			83	51				
	<u>240294</u>	<u>0265</u>	<u>277631</u>	<u>7640</u>				

Grade 2.

19299	18389	19145	17476
1414034	1354036	1380909	1324041
30	35	01	40
94	80	93	72
<u>345159</u>	<u>5155</u>	<u>274212</u>	<u>4234</u>
16507	1456060	18635	
1357359	51	1700508	
6060	11635	00	
01		40	
<u>352942</u>	<u>2922</u>	<u>168368</u>	<u>168380</u>

2000

Stars - lucanus

1913 Dec. 6.

	d	"	"	d	"	"
1	18076	1498	17479	15083		
152	13940	868	9018	13507		
315	4540	0809	11	10		
	65	81	58	76		
	<u>314130</u>	<u>4121</u>	<u>151551</u>	<u>1576</u>		
2	15705	19949	17049	15396		
19.0	13450	1219100	8098	14341		
10.3	5049	0500	9990	4032		
	99	66	29			
	<u>102259</u>	<u>2237</u>	<u>191065</u>	<u>1058</u>		
3	9995	71313	14900	14452		
277	9705	30	1252929	6812		
240	0099	6867	23	12		
			83	51		
	<u>240294</u>	<u>0265</u>	<u>277631</u>	<u>7640</u>		

Grade 2.

19299	18389	19545	17476
1414034	1354036	1380909	1324041
30	3536	01	46
94	80	93	72
<u>345159</u>	<u>5155</u>	<u>274212</u>	<u>4234</u>

108	16507	1456060	18635
359	135739	51	1700508
	6060	11635	00
	01		40
<u>352942</u>	<u>2922</u>	<u>168368</u>	<u>168380</u>

2
1
18.
16
2
2
18
16
3
1-
17
4
16
17.
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18.
MS
K
6
17.
17

2009

moon-measures.

d

4

N

d

x

N

$$\begin{array}{r}
 1 \\
 18.8 \\
 16.2 \\
 \text{min} \\
 16.1276 \\
 \hline
 \end{array}
 \begin{array}{r}
 11507 \\
 1022536 \\
 31 \\
 \hline
 \end{array}
 \begin{array}{r}
 11107 \\
 0500 \\
 9841 \\
 \hline
 1263
 \end{array}$$

$$\begin{array}{r}
 2 \\
 18.0 \\
 16.9 \\
 16.2751 \\
 \hline
 \end{array}
 \begin{array}{r}
 19970 \\
 1721911 \\
 11 \\
 52 \\
 \hline
 \end{array}
 \begin{array}{r}
 15390 \\
 812025 \\
 20 \\
 75 \\
 \hline
 2743
 \end{array}$$

$$\begin{array}{r}
 3 \\
 17.1 \\
 17.0 \\
 \hline
 \end{array}
 \begin{array}{r}
 19822 \\
 10968 \\
 5069 \\
 98 \\
 \hline
 17.1161
 \end{array}
 \begin{array}{r}
 12878 \\
 11721 \\
 2010 \\
 \hline
 1162
 \end{array}$$

$$\begin{array}{r}
 4 \text{ scratch} \\
 16.9 \\
 17.3 \\
 17.4426 \\
 \hline
 \end{array}
 \begin{array}{r}
 17625 \\
 1318988 \\
 89 \\
 00 \\
 \hline
 \end{array}
 \begin{array}{r}
 17758 \\
 1219589 \\
 88 \\
 48 \\
 \hline
 4438
 \end{array}
 \begin{array}{r}
 16788 \\
 1580009 \\
 1009 \\
 \hline
 169019
 \end{array}
 \begin{array}{r}
 1282607 \\
 0007 \\
 11846 \\
 \hline
 9035
 \end{array}$$

$$\begin{array}{r}
 5 \\
 16.8 \\
 18.1 \\
 \text{min} \\
 17.0 \\
 17.0 \\
 \hline
 \end{array}
 \begin{array}{r}
 18759 \\
 1665033 \\
 4633 \\
 36 \\
 \hline
 16.7889
 \end{array}
 \begin{array}{r}
 18129 \\
 1020092 \\
 98 \\
 18 \\
 \hline
 7923
 \end{array}
 \begin{array}{r}
 1383031 \\
 2731 \\
 13546 \\
 \hline
 17.0283
 \end{array}
 \begin{array}{r}
 14391 \\
 1410395 \\
 0195 \\
 \hline
 0291
 \end{array}$$

2000

Moon - measures

a

4

n

d

x

d

$$\begin{array}{r}
 1 \\
 158 \\
 162 \\
 \hline
 11507 \\
 1022136 \\
 31 \\
 \hline
 16.1276
 \end{array}$$

$$\begin{array}{r}
 11107 \\
 0500 \\
 9841 \\
 \hline
 1263
 \end{array}$$

$$\begin{array}{r}
 2 \\
 150 \\
 169 \\
 \hline
 19970 \\
 1721711 \\
 11 \\
 52 \\
 \hline
 16.2751
 \end{array}$$

$$\begin{array}{r}
 15390 \\
 812025 \\
 20 \\
 75 \\
 \hline
 2743
 \end{array}$$

3

$$\begin{array}{r}
 171 \\
 170
 \end{array}$$

$$\begin{array}{r}
 19822 \\
 10968 \\
 1058 \\
 98 \\
 \hline
 17.1161
 \end{array}$$

$$\begin{array}{r}
 12879 \\
 11721 \\
 2010 \\
 \hline
 1162
 \end{array}$$

4 scratch

$$\begin{array}{r}
 16.9 \\
 17.3 \\
 \hline
 17625 \\
 1318988 \\
 89 \\
 00 \\
 \hline
 17.4426
 \end{array}$$

$$\begin{array}{r}
 17758 \\
 1219159 \\
 88 \\
 48 \\
 \hline
 4438
 \end{array}$$

$$\begin{array}{r}
 16788 \\
 11800 \\
 1009 \\
 \hline
 16.9019
 \end{array}$$

$$\begin{array}{r}
 1282607 \\
 0007 \\
 11846 \\
 \hline
 9035
 \end{array}$$

5

$$\begin{array}{r}
 16.8 \\
 18.1
 \end{array}$$

$$\begin{array}{r}
 18.1 \\
 17.0 \\
 17.0
 \end{array}$$

$$\begin{array}{r}
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 \end{array}$$

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$$\begin{array}{r}
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 \end{array}$$

$$\begin{array}{r}
 17.0 \\
 17.0
 \end{array}$$

$$\begin{array}{r}
 18759 \\
 1665033 \\
 4633 \\
 36 \\
 \hline
 16.7859
 \end{array}$$

$$\begin{array}{r}
 18129 \\
 1020092 \\
 98 \\
 18 \\
 \hline
 7923
 \end{array}$$

$$\begin{array}{r}
 1383031 \\
 27 \\
 13546
 \end{array}$$

$$\begin{array}{r}
 14391 \\
 1410391 \\
 0191
 \end{array}$$

$$\begin{array}{r}
 17.0283
 \end{array}$$

$$\begin{array}{r}
 0291
 \end{array}$$

2
18
19

5
18
20
21

6
17
19

2009

moon's measures

a

y

n

d

n

1	1218072	11570
18.0	75	1039800
19.8	11010	99

19.8834.8829

6	10976
18.8	10070
20.0	7976

max

2	20.0301
4	

6 scratch

17.6	15660	19218
19.6	147571	15400.92
	73	92
	50	90
<u>19.6181</u>		<u>.6188</u>

15732	18900
11140	13475
35-35	6877
10	77
<u>17.5416</u>	<u>.5415</u>

possibly on
terminator

2009.

hydrogen lines

	a	y	m	d
2	121802		11570	
180	75		1039800	
188	11010		99	

1988348829

8	10976
188	10070
200	7976
2	<u>200301</u>

6 scratch

17.6	15660	19218
176	9475	15400
	7371	9292
	50	90
	<u>196181</u>	<u>6188</u>

15732	18900
11140	13475
31-31	687
10	77
<u>175416</u>	<u>5415</u>

possibly a
terminal

2009

Times etc.

Sept. 25 21^h 54^m ✓ - 22^h 06^m ✓
 Moon 21 59 59.1^s - 21 59 59.4^s
 clock slow 0 450^s

H. Sid T. 22 00 44.25^s ✓
 H. Thompson 4 44 31.05^s
 G. Sid T. 26 45 15.30^s ✓
 Sid T. he. Moon 12 15 44.58^s ✓
 Interval 14 29 30.72^s ✓
 Reduction 2 22.45^s ✓
 G. H. T. 14 27 08.27^s ✓ 6-α = -1^h 55^m ✓

From Kant Alue.

R.A.

Decl.

Moon 14^h 23^m 55^s 017.9^s - 1^h 57' 49.2^s
 Motion in 1^h 1.8088^s - 14.764^s
 " 27.1378^s + 49.09^s + 6 40.7^s
 Tabular place 23 55 50.88^s - 1 51 08.5^s

Moon's age 15-d.

parallel

55' 06.8^s ✓

semidiam

15' 02.6^s ✓

R

902.6^s ✓

Augmentation

+ 9.2

Parallax (2)

- 0.5

R

911.3^s ✓

R

1.9535^s ✓

(1+α) R

1.9522^s ✓R²3.8111^s ✓434 = 9.8^s ✓903 = 9.2^s ✓

α = -6.7

2009

Times etc.

Epitaph 1912 Sept. 25 21^m 54^m - 22^h 06^m
 - known 21 59 59.1 - 21 59 59.4
 clock slow 0 450

H. list T. 22 00 44.25
 1st hour 4 44 31.65
 G. list T. 26 45 15.30
 2nd T. in known 12 15 44.58
 Interval 14 29 30.72
 Reduction 2 22.45
 G. list T. 14 27 08.27 6-X = -1^h 55^m

From Kent Allen R. A. Place.
 known 14^m 23^m 55^m 01.79 - 1^h 57^m 49^s 2
 Interval 1^m 18088 - 14764
 27.1378 + 49.09 + 6 207
 Tabular place 23 55 50.88 - 1 51 08.5

Inconsistency 15-d.

parallel 55^m 06.8
 semidiam 15^m 02.6
 R 902.6
 Augmentation + 92
 Parallax + 0.5
 R
 R
 150/R 19522
 R² 38111

27.9223 345157

204
180
24

173
5

8009

Plate constants

15.1564	31.4126	23 55 16	-0 46 10
19.1062	10.2246	23 57 19	-3 31 02
27.7636	24.0280	0 01 48	-1 43 38
3 62.03	65.67	10 113 83	-4 120 50
20.68	21.89	23 58 08	-2 00 17
18	-22	- 1 23	+ 51
2.68	.11	23 56 45	-1 59 26
31	465		
83 ^s	51"		

$$\left. \begin{aligned} A &= 23^h 56^m 45^s \\ D &= -1^{\circ} 59' 26'' \end{aligned} \right\}$$

$$\begin{aligned} x - \bar{x} &+ 2.14 & + 6.7x & - 3.53 \\ + 186 + 66 &= + 252 + 102 &= + 354 &= +1 \\ + 204 + 21 &= + 225 + 128 &= + 353 &= 0 \\ + 117 + 50 &= + 167 + 186 &= + 353 &= 0 \\ 18.7435 + 38 & & + 126 &= 18.7246 \end{aligned}$$

$$\begin{aligned} y - \bar{y} &- 3.0x & + 9.24 & - 1.31 \\ - 113 - 45 &= - 158 + 289 &= + 131 &= 0 \\ + 94 - 57 &= + 37 + 94 &= + 131 &= 0 \\ - 8 - 83 &= - 91 + 221 &= + 130 &= -1 \\ 18.0792 - 56 & & + 166 &= 18.0771 \end{aligned}$$

Tables	$a = -1.0$	$c = -3.5$	$a - c = +2.5$	$b + d = +3.8$
Obs	$a = -6.7$	$c = -9.2$	$a - c = +2.5$	$b + d = +0.9$

151564	314126	23 55 16	-0 46 10
191062	102246	23 57 19	-3 31 02
272636	240250	0 01 48	-1 43 38
6203	6567	10 113 93	-4 120 50
2068	2159	23 58 08	-2 00 17
18	23	- 1 23	- 0 + 51
268	11	23 56 45	-1 59 26
31	25		
833	51"		

$$A = 23^h 56^m 45^s$$

$$D = -1^{\circ} 59' 26''$$

$$\begin{array}{rcl}
 2.3 & + 2.14 & + 6.72 & - 3.53 \\
 + 1.86 & + 6.6 & + 2.52 & + 1.02 & + 3.54 & = 1 \\
 + 2.04 & + 2.1 & + 2.25 & + 1.28 & + 3.53 & = 0 \\
 + 1.17 & + 1.0 & + 2.67 & + 1.86 & + 3.53 & = 0 \\
 187435 & + 38 & + 1.26 & & & = 187246
 \end{array}$$

$$\begin{array}{rcl}
 4.4 & - 3.02 & + 9.24 & - 1.31 \\
 - 1.13 & - 4.5 & - 1.58 & + 2.89 & + 1.31 & = 0 \\
 + 9.4 & - 5.7 & + 3.7 & - 9.4 & + 1.31 & = 0 \\
 - 8 & - 8.3 & - 9.1 & + 2.21 & + 1.30 & = -1 \\
 180792 & - 56 & + 1.66 & & & = 180771
 \end{array}$$

Tables	$a = -1.0$	$b = -3.5$	$a - b = +2.5$	$b + a = +3.1$
Obs	$a = -6.7$	$b = -9.2$	$a - b = +2.5$	$b + a = +0.9$

Cape No. 3 198.6

0 01 00.58
66
58

0 01 00.61
+ 36.87

0 01 37.48

23 56 45
+ 4 52.48
+ 292.46

2.46607

9.99999

0.97330

+ 9.4038

+ 56

27.4094

27.4223

+ 129

- 0° 26' 06.3

06.7

06.5

- 0 26 06.5

+ 4 00.6

- 0 22 05.9

- 1 59 26

+ 1 37 20.1

+ 584.17

3.76654

1.09769

7.8081m

19466

6.8081m

+ 12.5226

- 6

345220

345157

- 63

Cape No. 33.58

23 55 31.46
52
53

23 55 31.50
+ 36.87

23 56 08.37

23 56 45
- 36.63

1.56384m

0.00000

0.07108m

- -1.1778

- 4

16.8218

18.8374

+ 156

- 0 20 02.2

01.8

02.2

- 0 20 02.1

+ 4 00.5

- 0 16 01.6

- 1 59 26

+ 1 43 24.4

+ 62063

3.79283

1.12398

7.6686m

01422

48642m

+ 13.3040

- 0

353040

352932

- 108

2008 Slandand Coordinates.

Cape W. 3355 mag 7.1				Cape W. 3360 mag 5.1				Cape W. 4 mag 8.0			
C	23°	54'	39.13"	23°	56'	41.92"		0°	01'	11.49"	
L			13			98				50	
E	23	54	13			91				52	
mean	23	54	39.13	23	56	41.94		0	01	11.50	
Prece			+ 36.87			+ 36.88				+ 36.87	
α	23	55	1600	23	57	1882		0	01	4837	
A	23	56	45	23	56	45		23	56	45	
k-A	-	1	29.00	+	0	33.82		+	5	03.37	
sin(k-h)			- 89.00			+ 33.82				+ 303.35	
log.	7.949	39		1529	17			2.48	194		
"cos	9999	96		9999	18			9999	80		
"S.	0.456	59		0035	59			0.988	98		
3.	- 2.86	15		+ 1.08	54			+ 974	95		
3 ₁	-	7		+	4			+	24		
3	15.13	78		19.08	58			27.75	19		
α	15.15	64		19.10	62			27.76	36		
$\alpha - \beta$	+	186		+	204			+	117		
C	- 0°	50'	10.4"	- 3°	35'	02.6"		- 1°	47'	38.2"	
L			10.9			02.6				38.7	
E			11.5			03.1				39.2	
mean	- 0	50	10.9	- 3	35	02.8		- 1	47	38.7	
Prece	+	4	00.5	+	4	00.5		+	4	00.6	
δ	- 0	46	104	- 3	31	02.3		- 1	43	38.1	
D	- 1	59	26	- 1	59	26		- 1	59	26	
$\delta - D$	+ 1	13	15.6	- 1	31	36.3		+	15	47.9	
sin($\delta - D$)	+	439	6.3	- 549	7.6			+	947	9	
log.	3.64	309		3.74	017			2.97	676		
"mp	0.97	424		1.07	132			0.30	791		
tan S	8.12	81		878	86			8.47	95		
"3 ²	0.91	32		0.07	12			1.97	80		
" η	6.09	47		5.91	32			7.51	09		
η_0	+	9.42	40	- 11.78	47			+	203	20	
η_1	-	1		-	1			-	32		
η	31.42	39		10.21	52			24.02	88		
η	31.41	26		10.22	46			24.02	80		
$\eta - \eta_1$	- 1	13		+	94			-	8		

2000 Standard Coordinates

Cape W. 3355 mag 7.1

Cape W. 3360 mag 5.1

Cape W. 4 mag 8.0

C	23° 54' 39.13	23° 56' 41.92	0° 01' 11.49
L	13	98	50
E	23 54 13	91	52
beam	23 54 39.13	23 56 41.94	0 01 11.50
Pre	+ 36.87	+ 36.88	+ 36.87
A	23 55 16.00	23 57 18.82	0 01 48.37
A	23 56 45	23 56 45	25 50 45
X-A	- 1 29.00	+ 0 33.82	+ 5 03.37
sub(A)	- 89.00	+ 33.82	+ 303.35
log.	2.94939	1.52917	2.48194
mag	999996	999918	999980
I.	0.45659	0.03559	0.98898
3.	- 2.8615	+ 1.0854	+ 974.95
5.	- 7	+ 4	+ 24
3	15.1378	19.0358	27.7519
2	15.1569	19.1062	27.7636
5	+ 186	+ 204	+ 117

C	- 0° 50' 10.4	- 3° 35' 02.6	- 1° 47' 38.2
L	10.9	02.6	38.7
L	11.5	03.1	39.2
beam	0 50 10.9	- 2 35 02.8	- 1 47 38.7
Pre	+ 4 00.5	+ 4 00.5	+ 4 00.6
S	- 0 46 10.4	- 3 31 02.3	- 1 43 38.1
D	- 1 59 26	- 1 59 26	- 1 59 26
D + 1	13 15.6	- 1 31 36.3	+ 15 47.9
(d.1)	+ 4396.3	- 5997.6	+ 947.9
log	364309	3.74017	2.97676
mag	0.97424	1.07132	0.30791
mag	8.1281	8.7886	8.4795
3	0.9132	0.0712	1.9780
mag	6.0947	5.9132	7.5109
mag	+ 9.4240	- 11.7847	+ 20320
mag	- 1	- 1	- 32
mag	31.4239	10.2152	240288
mag	31.4126	10.2246	240280
mag	- 113	+ 194	- 8

pt	mag	resid
1	180.0	+20
2	202.4	-15
3	236.5	+8
4	251.0	-186
5	270.0	+26
6	298.1	-214
7	322.0	+89
8	337.6	-17
9	0.0	-33

over

2009 Moon's Center

	x	$x - x_0$	Δx	$(x - x_0)^2$	$(x - x_0)^2 + (y - y_0)^2$	$O - C$
1	18.7426	0.0000	+7	0.0000	3.8122	+11
2	18.0000	-0.7426	+6	0.5506	3.8075	-36
3	17.1162	-1.6264	+4	2.6439	3.8085	-26
4	16.9027	-1.8399	+2	3.3845	3.7889	-222 ^{1/2}
5	16.7906	-1.9520	0	3.8103	3.8103	-8
6	17.0287	-1.7139	-3	2.9385	3.7871	-240 ^{1/2}
7	17.5416	-1.2010	-5	1.4436	3.8186	+75
8	18.0000	-0.7426	-6	0.5523	3.8089	-22
9	18.7426	0.0000	-7	0.0000	3.8087	-24
Comp R^2					3.8111	

	y	$y - y_0$	Δy	$(y - y_0)^2$
-1	16.1270	-1.9520	-5	3.8122
2	16.2747	-1.8043	-4	3.2569
3	17.0000	-1.0790	-2	1.1646
4	17.4432	-0.6358	-1	0.4044
5	18.0790	0.0000	0	0.0000
6	19.0000	+0.9210	+2	0.8486
7	19.6184	+1.5394	+4	2.3710
8	19.8832	+1.8042	+4	3.2566
9	20.0301	+1.9511	+5	3.8087

Appl. Center

$$x = 18.0000$$

$$y = 16.2747$$

$$19.8832$$

$$3.61579$$

$$y_0 = 18.0790$$

$$y_{\text{min}} = 16.1270$$

$$R = 1.9520$$

$$x_{\text{max}} = 16.7906$$

$$x_0 = 18.7426$$

$$\text{Center} \begin{cases} x_0 = 18.7426 \\ y_0 = 18.0790 \end{cases}$$

2009 known Center

	x	$x - X_0$	Δx	$(x - X_0)^2$	$(x - X_0) + (y - Y_0)^2$	$O - C$
1	18.7420	0.0000	+7	0.0000	3.8122	+11
2	18.0000	-0.7426	+6	0.5506	3.8075	-36
3	17.1162	-1.6264	+4	2.6439	3.8085	-26
4	16.9027	-1.8399	+2	3.3845	3.7889	-222
5	16.7906	-1.9520	0	3.8103	3.8103	-4
6	17.0287	-1.7139	-3	2.9385	3.7871	-240
7	17.5416	-1.2010	-5	1.4436	3.8186	+75
8	18.0000	-0.7426	-6	0.5523	3.8089	-22
9	18.7426	0.0000	-7	0.0000	3.8087	-24

$\sum (x - X_0)^2 = 3.8111$
 $\sum (y - Y_0)^2 = 3.8111$

	y	$y - Y_0$	Δy	$(y - Y_0)^2$
-1	16.1270	-1.9520	-5	3.8122
2	16.2747	-1.8043	-4	3.2569
3	17.0000	-1.0790	-2	1.1646
4	17.4432	-0.6358	-1	0.4044
5	18.0790	0.0000	0	0.0000
6	19.0000	+0.9210	+2	0.8486
7	19.6184	+1.5394	+4	2.3710
8	19.8832	+1.8042	+4	3.2566
9	20.0301	+1.9511	+5	3.8087

Apfr Center

$$x = 18.0000$$

$$y = 16.2747$$

$$19.8832$$

$$36.1579$$

$$Y_0 = 18.0790$$

$$y_{\text{min}} = 16.1270$$

$$R = 1.9520$$

$$x_{\text{min}} = 16.7906$$

$$X_0 = 18.7426$$

$$\text{Center} \begin{cases} X_0 = 18.7426 \\ Y_0 = 18.0790 \end{cases}$$

Formation of moments

	ah	an	bn
1	- 0,00	+ 0,0	- 21,6
2	+ 1,33	+ 26,7	+ 64,8
3	+ 1,76	+ 42,4	+ 28,1
4	+ 0,30	+ 102,1	+ 35,5
5	- 0,00	+ 15,6	- 0,0
6	- 0,39	+ 102,8	- 55,2
7	- 1,85	- 90,1	+ 115,2
8	- 1,33	+ 16,2	- 39,6
9	+ 0,00	- 0,0	- 46,8
	- 0,18	+ 213,7	+ 80,4

Residuals

	O		G	O - G
1	+ 11	+ 0 - 9	- 9	+ 20
2	- 36	- 15 - 8	- 23	- 13
3	- 26	- 33 - 5	- 38	+ 12
4	- 222	- 37 - 3	- 40	- 182
5	- 8	- 40 0	- 40	+ 32
6	- 240	- 35 + 4	- 31	- 209
7	+ 75	- 24 + 7	- 17	+ 92
8	- 22	15 + 4	- 7	- 15
9	- 24	- 0 + 9	+ 9	- 33

2009 Morris Center Conditional Equations

	a	b	0	c	0-c
1	0.00	-1.915	+11	+ 0 - 9 = -9	+20
2	-0.74	-1.80	-36	- 13 - 8 = -21	-15
3	-1.63	-1.08	-26	- 29 - 5 = -34	+8
4	-1.84	-0.64	-222	- 33 - 3 = -36	-186
5	-1.95	+0.00	-8	- 34 + 0 = -34	+26
6	-1.71	+0.92	-240	- 30 + 4 = -26	-214
7	-1.20	+1.54	+75	- 21 + 7 = -14	+89
8	-0.74	+1.80	-22	- 13 + 8 = -5	-17
9	0.00	+1.95	-24	+ 0 + 9 = +9	-33
					Average = 6.7

Normal Equations

$$\begin{aligned}
 +12.16 - 0.18 &= +21.4 \\
 -0.18 + 18.30 &= +80 \\
 +0.18 - 0.00 &= +3 \\
 +18.30 &= +83 \\
 +12.16 &= +21.4 + 1 = +21.5
 \end{aligned}$$

$$\begin{aligned}
 b &= +4.5 \\
 a &= +17.7
 \end{aligned}$$

Adjusted Solution giving (4) + (6) half wt

$$\begin{aligned}
 +10.58 - 0.18 &= +21.4 \\
 +0.18 + 17.98 &= +80 \\
 +0.18 - 0.00 &= +4 \\
 +17.98 &= +84 \\
 +10.58 &= +21.4 + 1 = +21.5
 \end{aligned}$$

$$\begin{aligned}
 b &= +4.7 \\
 a &= +20.4
 \end{aligned}$$

2009

Innos Center

Conditional Equations

	a	b	c		a	b-c
1	0.00	-1.91	+1.1	+ 0 - 9 =	-9	+20
2	-0.74	-1.80	-36	-13 - 8 =	-21	-15
3	-1.63	-1.08	-26	-29 - 5 =	-34	+8
4	-1.84	-0.64	-222	-33 - 3 =	-36	-186
5	-1.95	+0.00	-8	-39 + 0 =	-39	+26
6	-1.71	+0.92	-240	-30 + 9 =	-26	-214
7	-1.20	+1.54	+75	-21 + 7 =	-14	+89
8	-0.74	+1.80	-22	-13 + 8 =	-5	-17
9	0.00	+1.95	-24	+ 0 + 9 =	+9	-33

Average = 6.7

Normal Equations

$$\begin{aligned}
 +12.16 &= 0.18 = +21.4 \\
 -0.18 &+ 18.30 = +80 \\
 +0.18 &= 0.00 = +3 \\
 &+ 18.30 = +83 \\
 +12.16 &+ 21.4 + 1 = +21.5
 \end{aligned}$$

$$\begin{aligned}
 b &= +4.5 \\
 a &= +17.7
 \end{aligned}$$

Amended Solution from (4) + (6) half wt

$$\begin{aligned}
 +10.58 &- 0.18 = +21.4 \\
 -0.18 &+ 17.98 = +80 \\
 +0.18 &= 0.00 = +4 \\
 &+ 17.98 = +84
 \end{aligned}$$

$$b = +4.7$$

$$+10.58 = +21.4 + 1 = +21.5$$

$$a = +20.4$$

2009 Moon's Mean Position (1912.0)

$$\begin{array}{r}
 X_0 = 18.7426'' \\
 \frac{1}{2}a = \quad + 9'' \\
 \hline
 18.7435''
 \end{array}
 \qquad
 \begin{array}{r}
 Y_0 = 18.0790'' \\
 \frac{1}{2}b = \quad + 2'' \\
 \hline
 18.0792''
 \end{array}$$

Jupiter's constant $X = 18.7246''$ $Y = 18.0771''$

$$Z = +0.7246''$$

$$\eta = -3.9229''$$

$$\begin{array}{r}
 \log Z = 9.86010'' \\
 \therefore \cos S = 9.99959'' \\
 \therefore \cos t = 8.50724
 \end{array}$$

$$\begin{array}{r}
 \log \tan S = 8.6254'' \\
 \therefore S^2 = 9.7202'' \\
 \therefore \eta_1 = 5.3990
 \end{array}$$

$$\therefore (X-A) = 1.35327''$$

$$\begin{array}{r}
 \therefore \eta_0 = 0.59361'' \\
 \quad \quad \quad 733115'' \\
 \hline
 3.26246''
 \end{array}$$

$$X-A = \quad + \quad 22.56''$$

$$A = 23 \quad 56 \quad 45''$$

$$S-D = \quad - \quad 30 \quad 30.0''$$

$$\alpha_0 = 23 \quad 57 \quad 07.56''$$

$$D = \quad - \quad 1 \quad 59 \quad 26''$$

$$\text{Reduction} + 3.29''$$

$$S_0 = \quad - \quad 2 \quad 29 \quad 56.0''$$

$$X' = 23 \quad 57 \quad 10.85''$$

$$\text{Red.} \quad + \quad 21.1''$$

$$S' = \quad - \quad 2 \quad 29 \quad 34.9''$$

2009 known known Position (1912 U)

$$\begin{array}{r}
 X = 18.7426 \quad Y = 18.0790 \\
 \hline
 + 9 \quad + 2 \\
 \hline
 18.7435 \quad 18.0792
 \end{array}$$

From Plate constant $X = 18.7246 \quad Y = 18.0771$

$$Z = +0.7246$$

$$\eta = -3.9229$$

$$\log Z = 9.86010$$

$$\cos \delta = 999959$$

$$\sin \delta = 850724$$

$$\log \cos \delta = 8.6254$$

$$\log \sin \delta = 9.7202$$

$$\eta_1 = 5.3990$$

$$(X - A) = 1.35327$$

$$\eta_2 = 0.59361$$

$$X - A = + 2256$$

$$7.33115$$

$$3.26246$$

$$A = 23 \quad 56 \quad 45$$

$$S - D = - 30 \quad 30 \quad 0$$

$$X_0 = 23 \quad 57 \quad 07.56$$

$$D = -1 \quad 59 \quad 26$$

$$\text{Red. and opp.} = 329$$

$$S_0 = -2 \quad 29 \quad 56.0$$

$$X = 23 \quad 57 \quad 10.85$$

$$\text{Red.} = + 21.1$$

$$S = -2 \quad 29 \quad 34.9$$

Red. ad. C. app.

$$\begin{array}{rcl}
 H + \alpha_0 & 5^{\circ} 45' 56'' 15' \\
 + H & 5^{\circ} 48' \\
 \alpha_0 & = 23 \ 57 \\
 G & 21 \ 36 \\
 G + \alpha_0 & 21 \ 33 = 323^{\circ} 15'
 \end{array}$$

$$\delta_0 = -2^{\circ} 30'$$

$$\begin{array}{rcl}
 \log i & = & 0.9105 \\
 \log 8 & = & 9.9996 \\
 \hline
 \therefore (i) & = & 0.9101
 \end{array}$$

$$\begin{array}{rcl}
 \log \cos (H + \alpha_0) & = & 9.9038 \\
 \therefore \cos & = & 1.2103 m \\
 \therefore \sin (G + \alpha_0) & = & 9.7769 m \\
 \therefore \tan S & = & 8.6401 m \\
 \therefore \frac{1}{\cos} & = & 8.8239
 \end{array}$$

$$\begin{array}{rcl}
 \log (g') & = & 1.1141 \\
 \therefore (g) & = & 84512
 \end{array}$$

$$\begin{array}{rcl}
 \log \cos (H + \alpha_0) & = & 8.8156 \\
 \therefore \sin \delta_0 & = & 8.6347 m \\
 \therefore \sin & \checkmark & 1.2737 \\
 \therefore \sin (H + \alpha_0) & = & 9.9991 \\
 \therefore \sec S & = & 0.0004 \\
 \therefore \frac{1}{\cos} & = & 8.8239
 \end{array}$$

$$\begin{array}{rcl}
 \log (h') & = & 8.7290 m \\
 \therefore (h) & = & 0.0971
 \end{array}$$

$$\begin{array}{rcl}
 f & = & +2.01 \\
 (g) & = & +0.03 \\
 (h) & = & +1.25 \\
 \hline
 & = & +3.29 \checkmark
 \end{array}$$

$$\begin{array}{rcl}
 (g') & = & +1.300 \\
 (h') & = & -0.05 \\
 (i) & = & +8.13 \\
 \hline
 & = & +21.08 \checkmark
 \end{array}$$

Red. ad. E. app.

S. - 2° 30'

$$\begin{array}{rcl}
 H + \lambda & 5^{\circ} & 45' 56'' 15'' \\
 + & 5^{\circ} & 48' \\
 \hline
 \lambda & = & 23 \quad 57 \\
 G & & 21 \quad 36 \\
 G + \lambda & & 21 \quad 33 - 323'' 15''
 \end{array}$$

$$\begin{array}{rcl}
 \log \lambda & = & 0.91057 \\
 \log S & = & 9.9996 \\
 \hline
 G & = & 0.9101
 \end{array}$$

$$\begin{array}{rcl}
 \log \cos (H + \lambda) & = & 9.9038 \\
 \log & & 1.2103 \\
 \log (K + \lambda) & = & 9.7709 \\
 \log S & = & 8.6401 \\
 \hline
 & = & 8.8229
 \end{array}$$

$$\begin{array}{rcl}
 \log (S) & = & 1.1147 \\
 S & = & 84512
 \end{array}$$

$$\begin{array}{rcl}
 \log \cos (H + \lambda) & = & 8.8156 \\
 \log S & = & 8.6397 \\
 \hline
 & = & 1.2737 \\
 \log (H + \lambda) & = & 9.9991 \\
 \log S & = & 0.0004 \\
 \hline
 & = & 8.8229
 \end{array}$$

$$\begin{array}{rcl}
 \log (S) & = & 8.7290 \\
 S & = & 0.0971
 \end{array}$$

$$\begin{array}{rcl}
 f & = & +2.01 \\
 S & = & +0.03 \\
 G & = & +1.25 \\
 \hline
 & = & +3.29
 \end{array}$$

$$\begin{array}{rcl}
 S & = & +1.300 \\
 G & = & -0.05 \\
 \hline
 & = & +8.13 \\
 +2.108
 \end{array}$$

2009

Lunar Parallax.

$$\alpha' = 23^m 57^s 10.85^{\circ}$$

$$\theta = 22 \quad 00 \quad 44.25^{\circ}$$

$$\delta - \alpha' = -1 \quad 56 \quad 26.6^{\circ}$$

$$= -29^{\circ} 06' 40''$$

$$- \quad \quad \quad 9 \quad 56^{\circ}$$

$$- 28 \quad 56 \quad 44^{\circ}$$

$$9.95727^{\circ}$$

$$0.00000$$

$$\underline{005795^{\circ}}$$

$$0.01522^{\circ}$$

$$\gamma = 46 \quad 00 \quad 14.0^{\circ}$$

$$\delta = 2 \quad 29 \quad 34.9^{\circ}$$

$$\gamma - \delta = 48 \quad 29 \quad 48.9^{\circ}$$

$$9.82640^{\circ}$$

$$8.20495^{\circ}$$

$$9.87444^{\circ}$$

$$\underline{0.14305^{\circ}}$$

$$8.04885^{\circ}$$

$$\delta - \delta' = +38 \quad 28.3$$

$$\delta = -1 \quad 51 \quad 06.8^{\circ}$$

$$\text{Corrected } \delta = -1 \quad 51 \quad 08.5^{\circ}$$

$$O-C \quad \quad \quad + \quad 1.9^{\circ}$$

$$\delta' = -2 \quad 29 \quad 34.9^{\circ}$$

$$\delta = -1 \quad 51 \quad 06.8^{\circ}$$

$$9.86913^{\circ}$$

$$8.20495^{\circ}$$

$$9.68709^{\circ}$$

$$\underline{000023^{\circ}}$$

$$7.76148^{\circ}$$

$$\alpha - \alpha' = -19' \quad 50.8''$$

$$- \quad 1^m \quad 19.39^{\circ}$$

$$\alpha = 23 \quad 55 \quad 58.46^{\circ}$$

$$\alpha = 23 \quad 55 \quad 50.88^{\circ}$$

$$+ \quad 0.58^{\circ}$$

2009

Lunar Parallax

$$\alpha' = 23^\circ 57' 10.85''$$

$$\delta = 22^\circ 00' 44.25''$$

$$\alpha - \alpha' = -1^\circ 56' 26.6''$$

$$= -29^\circ 06' 40''$$

$$= 9^\circ 56'$$

$$= 28^\circ 56' 44''$$

$$995727$$

$$000000$$

$$005795$$

$$0.01522$$

$$y = 46^\circ 00' 14.0''$$

$$s = 2^\circ 29' 39.4''$$

$$y - s = 48^\circ 29' 48.9''$$

$$9.82640$$

$$820495$$

$$967444$$

$$014305$$

$$804884$$

$$\delta - \delta' = +38^\circ 28.3''$$

$$s = 1^\circ 51' 06.6''$$

$$\text{Circ. Eph. } s = -1^\circ 51' 08.5''$$

$$0 - c = +19''$$

$$s' = -2^\circ 29' 34.9''$$

$$s = \cancel{1^\circ 51' 06.6''} - 1^\circ 51' 06.6''$$

$$9.86913$$

$$820495$$

$$968709$$

$$000023$$

$$776140$$

$$\alpha - \alpha' = -19^\circ 50.78''$$

$$= 1^\circ 19.39''$$

$$\alpha = 23^\circ 55' 56.46''$$

$$\alpha = 23^\circ 55' 50.88''$$

$$+ 0.58''$$

