

ANNEX J TO
CRITIQUE OF ALL NASA MARS WEATHER DATA, WITH EMPHASIS ON PRESSURE:
Concessions by Ashima Research and How to Correctly Calculate Daylight Hours for MSL

This Annex was originally designed to correct disinformation about sunrise/sunset times at MSL. We used this pattern to raise a charge that all related Martian weather data is suspect. Ashima Research claimed to have derived its weather facts from the REMS Team, but sunrise/sunset times were never incorporated in the public reports that the REMS Team put out, so these mistakes would seem to belong to Ashima alone. It appears that Ashima essentially incorporated all our suggestion into their revised reports, although we suspect that a published report by them that the low temperature at MSL dropped from -75°C on June 3, 2013 (Sol 293) to -114°C on June 5, 2013 (Sol 295) is bogus. Temperatures were remarkably stable for the previous 292 sols, with lows from the minus mid 60s to the minus 70s.

THE LONG SOUGHT ASHIMA RESEARCH CONCESSION POST.

From September 2012 through May 2013 we pointed out Ashima errors in conjunction with sunrise/sunset times and winds posted that made no sense. Finally they issued the following concession on May 10, 2013:

Weather app update

Posted on [May 10, 2013](#) by [Chris](#)

For the first 268 sols of data collected by REMS we've archived the XML data files published by [CAB](#) without any modifications. We also collected these files into a *REMS_climate* file that powers our [mobile HTML5 app](#).

We've known about a few small flaws in the data stream for a while, including the lack of wind data, occasional copy-paste errors and changes in the language used for terrestrial dates (the files are manually updated). However, this is not the 'science' data (which can be found on NASA's [Planetary Data System](#)) and this site is not maintained by/for the REMS science team. So, while we can guess at corrections to the data, we don't add or create data without a very good reason.

Last month, [spaceappschallenge](#) launched a project called "[Wish You Were Here](#)" to provide an "interesting representation of weather on Mars" using the REMS public feed. This led to most (if not all) of the participating groups to base their projects on our archived data feed and blame us for the errors they found. A few even tried to correct the data and added in new and interesting errors while doing so.

We can't fix all of the data, but the data we release now contains a few extra values related to time on Mars that we calculate using our [Python tools](#) that we also use in our [Data Assimilation](#) project. The new data does not replace the old data, which still exists in the files, but we've added some fields to provide our best estimates of the timing data. Some of the projects formed in the [spaceappschallenge](#) have archived our dataset, so it might take them a while to update, but the data is [live in our weather app right now!](#)

In detail, we have:

1. Calculated the *sunrise and sunset times at MSL in Mean and True Solar Times. These values are much better than the fixed values provided by the original data, but still rely on some assumptions.* We assume that the mission Sol in question is referenced correctly in the original data and calculate the Mars Solar Date and J2000 ephemeris offset using this data. Once this date is found we (mathematically) look for the sunrise and sunset, noting the times it happens. Times are now given in a 24 hour clock format.

2. Calculated the Heliocentric Longitude, Ls. These calculated values rely on the same assumption about Sol number as the sunrise/sunset calculation. It turns out the original data is pretty close to our calculated values so we think the original data is correct. The difference between the two is in the origin of those values used to calculate Ls. Our Ls comes directly from the Sol number. The original CAB Ls may have a better source for this value in the raw data, or they may start from the “posted” Earth date.

3. Removed the wind speed and direction data.

4. Normalized the ‘posted’ or ‘terrestrial date’ to an ISO standard format. In our weather app (that has been running since MSL landed!) we present the date in a format determined by your Locale settings.

(As a reminder, neither the original nor calculated data provided by the app should be relied on for mission planning, weather forecasting, or conspiracy theories. NASA provides many free tools to find the time on Mars with *extremely good accuracy* if you need it.)

Exact times of sunrise and sunset are important in discussions relating the frequent inverse relationship seen between temperature and pressure for Viking 1, Viking2, and MSL – all of which employed radio thermoelectric generators. The affects of these heaters and other cyclic heat sources on pressure transducers are of prime interest.

Ashima took the liberty of altering the REMS reports of September 1 to September 5, which had shown the pressure to be between 742 and 747 hPa (Mbar), pressure often equal to that of Vail, Colorado.

Our taxpayers paid ~\$2,500,000,000 for the MSL lander. Earlier I wrote that for that “we received a set of data that is easy to refute. Ashima and the REMS Team owe the public an apology, and an admission that corrections noted in this report are true.” The retraction on their part was a good start, but the real issue remains pressure. If pressures shown by the REMS Team for September 1 to 5, 2013 turn out to be true, then Mars is much more like the Earth than we have been led to believe.

MARTIAN DAYLIGHT CALCULATIONS BY DAVID A. ROFFMAN

The first step is to specify the latitude, ϕ . For purposes of this calculation, the latitude used was the actual latitude of the MSL on Mars, namely 4.59° South (written as -4.59). Next the declination (δ) must be calculated:

$$\delta = \arcsin((\sin(25.19) * \sin(\lambda_{\text{sun}})).$$

The required input is the L_s , which is λ_{sun} . The hour angle is then $H = \arccos((\sin(-.17) - \sin(\phi) * \sin(\delta)) / (\cos(\phi) * \cos(\delta)))$.

This output must be in degrees. A reference speaks of calculating the solar transit (local noon). However, it also notes that the sunrise and sunset times are the local noon time $-/+ 1.027491 * H / 360$. By taking the equations for sunrise and sunset times (the actual formulae for the Julian dates are irrelevant as they share a common term that will be canceled) and subtracting the sunrise from the sunset one, a number is obtained. This is the time interval between the sunset and sunrise times, and is hence the length of day. The length of day is: $2 * 1.027491 * H / 360$. Multiply by 24 to get hours. The table that follows indicates what the total hours and minutes are for each L_s (solar longitude). The L_s can be related to a specific date via the on-line calculator at http://www-mars.lmd.jussieu.fr/mars/time/martian_time.html. The tables give only the numbers of hours and minutes of daylight. Or a sol with 12 hours 10 minutes of daylight, half that time is before local noon and half the time is after local noon, so such a day would have sunrise at 5:55 and sunset at 18:05. The actual time may vary slightly as a result of local topography. For example, MSL is headed for Mount Sharp which rises ~ 5 km from the valley floor, although the top of the mountain is only about 838 m above MOLA areoid (http://wray.eas.gatech.edu/Wray2012_GaleReview-acceptedIJA.pdf). Ashima Research rounds off its sunrise *and* sunset times to the nearest minute, so this fact alone can contribute up to a minute of difference between our calculations and any figures they publish. It appears that their new set of figures is almost always with one or two minutes of our calculation, is based on Mars being a perfect sphere (another small source of error).

Understanding where Mars is in its orbit. The solar longitude L_s is the Mars-Sun angle, measured from the Northern Hemisphere spring equinox where $L_s=0$. $L_s=90$ thus corresponds to summer solstice, just as $L_s=180$ marks the autumn equinox and $L_s=270$ the winter solstice (all relative to the northern hemisphere). In trying to understand where Mars is in its orbit, it's important to know that while all Martian months involve a change of 30 degrees, there is a large variation in number of days in each of the 12 months there, and also a large variation in angular speed around the sun (see Figure 1 and Table 1 below). In working up estimates for the length of any given day I used Table 2. This allowed me to project within a day or 2 over the Martian year where the planet would be, so that I could compare the length of day on Mars with a similar position in Earth's orbit. Small errors were introduced where the daily rate of change in L_s was not quite the monthly average shown in the last column of Table 2, especially around perihelion.

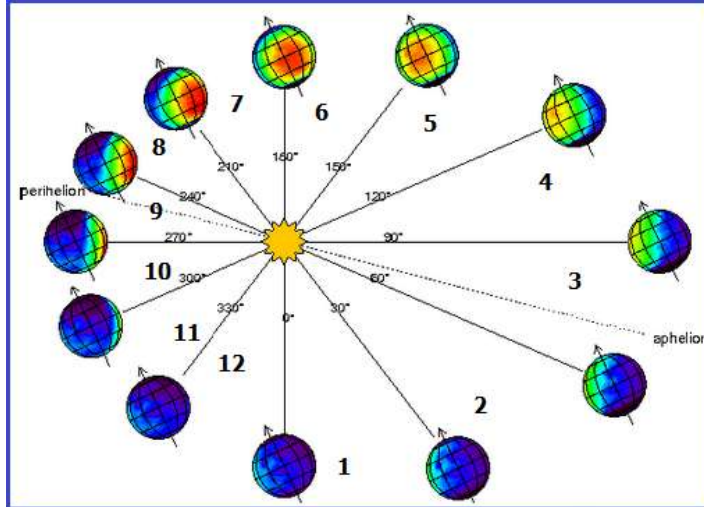


Figure 1 above – Position of Mars at the start of each of its 12 months. Perihelion occurs between month 8 and 9, aphelion in between month 2 and 3. As per table 2 below, Mars experience its greatest ΔL s in degrees per day around perihelion.

TABLE 1 – THE MARTIAN MONTHLY CALENDAR					
MARS MONTH/	END SOL	START SOL	DAYS	Degrees per month	ΔL s Degrees per Day
1	61	0	61	30	0.491803
2	127	61	66	30	0.454545
3	193	127	66	30	0.454545
4	258	193	65	30	0.461538
5	318	258	60	30	0.5
6	372	318	54	30	0.555556
7	422	372	50	30	0.6
8	468	422	46	30	0.652174
9	515	468	47	30	0.638298
10	562	515	47	30	0.638298
11	613	562	51	30	0.588235
12	669	613	56	30	0.535714

λ_{sun} (0 for spring in northern hemisphere) This is Ls	Latitude (phi)	$\delta_{degrees} =$ $\arcsin((\sin(25.19) * \sin(\lambda_{sun}))$	$H = \arccos((\sin(-.17) -$ $\sin(lw) * \sin(\delta)) / (\cos(lw) *$ $\cos(\delta)))$	Day Length = $2 * 1.027491 * H / 360$	Daylight In Hours David's Calculation (=E value * 24)	Half Sol in Hours	Difference Half day - Daylight (G-F)	Minutes above or below 12 hours for daylight	Hours + minutes of daylight	
									Hours	Min.

0	-4.59	0	90.17054697	0.51471903	12.35325673	12.329895	0.023362	1.40170306	12 hr	1.401703
1	-4.59	0.425603669	90.13638243	0.51452401	12.34857623	12.329895	0.018681	1.12087298	12 hr	1.120873
2	-4.59	0.851101167	90.10223209	0.51432907	12.34389767	12.329895	0.014003	0.8401597	12 hr	0.84016
3	-4.59	1.276386306	90.06810071	0.514134238	12.33922172	12.329895	0.009327	0.55960221	12 hr	0.559602
4	-4.59	1.701352853	90.03399304	0.513939542	12.33454901	12.329895	0.004654	0.27923957	11 hr	0.27924
5	-4.59	2.125894518	89.99991384	0.513745008	12.3298802	12.329895	-1.48E-05	-0.00088898	11 hr	59.99911
6	-4.59	2.549904928	89.96586793	0.513550664	12.32521595	12.329895	-0.004679	-0.28074393	11 hr	59.71926
7	-4.59	2.973277609	89.93186014	0.513356538	12.32055692	12.329895	-0.009338	-0.56028545	11 hr	59.43971
8	-4.59	3.395905971	89.89789539	0.513162658	12.31590379	12.329895	-0.013991	-0.83947332	11 hr	59.16053
9	-4.59	3.817683284	89.86397861	0.512969051	12.31125723	12.329895	-0.018638	-1.11826682	11 hr	58.88173
10	-4.59	4.23850266	89.83011482	0.512775747	12.30661793	12.329895	-0.023277	-1.39662469	11 hr	58.60338
11	-4.59	4.658257039	89.79630913	0.512582775	12.3019866	12.329895	-0.027908	-1.67450502	11 hr	58.32549
12	-4.59	5.076839171	89.76256672	0.512390164	12.29736393	12.329895	-0.032531	-1.95186522	11 hr	58.04813
13	-4.59	5.494141598	89.72889286	0.512197944	12.29275065	12.329895	-0.037144	-2.22866191	11 hr	57.77134
14	-4.59	5.910056641	89.69529294	0.512006146	12.2881475	12.329895	-0.041748	-2.50485086	11 hr	57.49515
15	-4.59	6.324476385	89.66177244	0.511814801	12.28355523	12.329895	-0.04634	-2.78038691	11 hr	57.21961
16	-4.59	6.737292666	89.62833699	0.511623942	12.27897461	12.329895	-0.05092	-3.05522391	11 hr	56.94478
17	-4.59	7.148397059	89.59499233	0.511433601	12.27440643	12.329895	-0.055489	-3.32931467	11 hr	56.67069
18	-4.59	7.557680868	89.56174433	0.511243812	12.2698515	12.329895	-0.060044	-3.60261083	11 hr	56.39739
19	-4.59	7.965035114	89.52859902	0.51105461	12.26531063	12.329895	-0.064584	-3.87506286	11 hr	56.12494
20	-4.59	8.370350533	89.49556259	0.510866028	12.26078468	12.329895	-0.06911	-4.14661995	11 hr	55.85338
21	-4.59	8.773517562	89.46264138	0.510678105	12.25627451	12.329895	-0.07362	-4.41722994	11 hr	55.58277
22	-4.59	9.17442634	89.42984189	0.510490876	12.25178102	12.329895	-0.078114	-4.68683933	11 hr	55.31316
23	-4.59	9.572966702	89.39717083	0.51030438	12.24730513	12.329895	-0.08259	-4.95539311	11 hr	55.04461
24	-4.59	9.969028179	89.36463506	0.510118657	12.24284777	12.329895	-0.087047	-5.22283479	11 hr	54.77717

λ_{sun} (0 for spring in northern hemisphere) This is Ls	Latitude (phi)	$\delta_{degrees} =$ $\arcsin((\sin(25.19) * \sin(\lambda_{sun}))$	$H = \arccos((\sin(-.17) -$ $\sin(lw) * \sin(\delta)) / (\cos(lw) *$ $\cos(\delta)))$	Day Length = $2 * 1.027491 * H / 360$	Daylight In Hours David's Calculation (=E value * 24)	Half Sol in Hours	Difference Half day - Daylight (G-F)	Minutes above or below 12 hours for daylight	Hours + minutes of daylight	
									Hours	Min.

25	-4.59	10.3625	89.33224165	0.509933746	12.23840991	12.329895	-0.091485	-5.48910631	11 hr	54.51089
26	-4.59	10.75327109	89.29999786	0.509749689	12.23399255	12.329895	-0.095902	-5.75414796	11 hr	54.24585
27	-4.59	11.14123007	89.26791115	0.509566529	12.22959671	12.329895	-0.100298	-6.01789839	11 hr	53.9821
28	-4.59	11.52626529	89.2359892	0.50938431	12.22522344	12.329895	-0.104672	-6.2802945	11 hr	53.71971
29	-4.59	11.90826481	89.20423991	0.509203076	12.22087382	12.329895	-0.109021	-6.54127143	11 hr	53.45873
30	-4.59	12.28711642	89.17267137	0.509022874	12.21654897	12.329895	-0.113346	-6.80076253	11 hr	53.19924
31	-4.59	12.66270765	89.14129193	0.508843751	12.21225002	12.329895	-0.117645	-7.05869928	11 hr	52.9413
32	-4.59	13.0349258	89.11011015	0.508665757	12.20797816	12.329895	-0.121917	-7.31501128	11 hr	52.68499
33	-4.59	13.40365796	89.07913482	0.508488941	12.20373458	12.329895	-0.12616	-7.56962624	11 hr	52.43037
34	-4.59	13.76879101	89.04837498	0.508313355	12.19952051	12.329895	-0.130374	-7.82246991	11 hr	52.17753
35	-4.59	14.13021166	89.0178399	0.508139052	12.19533724	12.329895	-0.134558	-8.07346609	11 hr	51.92653
36	-4.59	14.48780649	88.98753908	0.507966086	12.19118607	12.329895	-0.138709	-8.32253663	11 hr	51.67746
37	-4.59	14.84146195	88.95748228	0.507794513	12.18706832	12.329895	-0.142827	-8.56960138	11 hr	51.4304
38	-4.59	15.19106443	88.92767948	0.507624391	12.18298538	12.329895	-0.14691	-8.81457822	11 hr	51.18542
39	-4.59	15.53650028	88.89814092	0.507455776	12.17893863	12.329895	-0.150956	-9.05738304	11 hr	50.94262
40	-4.59	15.87765582	88.86887707	0.50728873	12.17492952	12.329895	-0.154965	-9.29792978	11 hr	50.70207
41	-4.59	16.21441747	88.83989864	0.507123313	12.17095951	12.329895	-0.158936	-9.5361304	11 hr	50.46387
42	-4.59	16.54667169	88.81121657	0.506959587	12.1670301	12.329895	-0.162865	-9.77189496	11 hr	50.22811
43	-4.59	16.87430512	88.78284203	0.506797617	12.16314282	12.329895	-0.166752	-10.0051316	11 hr	49.99487
44	-4.59	17.19720459	88.75478643	0.506637468	12.15929924	12.329895	-0.170596	-10.2357466	11 hr	49.76425
45	-4.59	17.51525716	88.72706138	0.506479206	12.15550094	12.329895	-0.174394	-10.4636445	11 hr	49.53636
46	-4.59	17.82835026	88.69967872	0.506322898	12.15174955	12.329895	-0.178145	-10.688728	11 hr	49.31127
47	-4.59	18.13637166	88.67265049	0.506168613	12.14804671	12.329895	-0.181848	-10.9108982	11 hr	49.0891
48	-4.59	18.43920959	88.64598892	0.506016421	12.14439411	12.329895	-0.185501	-11.1300544	11 hr	48.86995
49	-4.59	18.73675284	88.61970643	0.505866393	12.14079344	12.329895	-0.189102	-11.3460945	11 hr	48.65391

λ_{sun} (0 for spring in northern hemisphere) This is Ls	Latitude (phi)	$\delta_{degrees} =$ $\arcsin((\sin(25.19) * \sin(\lambda_{sun}))$	$H = \arccos((\sin(-.17) -$ $\sin(lw) * \sin(\delta)) / (\cos(lw) *$ $\cos(\delta)))$	Day Length = $2 * 1.027491 * H / 360$	Daylight In Hours David's Calculation (=E value * 24)	Half Sol in Hours	Difference Half day - Daylight (G-F)	Minutes above or below 12 hours for daylight	Hours + minutes of daylight	
									Hours	Min.

50	-4.59	19.02889074	88.59381562	0.505718601	12.13724643	12.329895	-0.192649	-11.5589151	11 hr	48.44108
51	-4.59	19.31551336	88.56832925	0.505573118	12.13375483	12.329895	-0.19614	-11.7684112	11 hr	48.23159
52	-4.59	19.59651149	88.54326023	0.505430017	12.1303204	12.329895	-0.199575	-11.9744768	11 hr	48.02552
53	-4.59	19.87177679	88.5186216	0.505289372	12.12694494	12.329895	-0.20295	-12.1770045	11 hr	47.823
54	-4.59	20.14120185	88.49442652	0.50515126	12.12363024	12.329895	-0.206265	-12.3758864	11 hr	47.62411
55	-4.59	20.4046803	88.47068824	0.505015755	12.12037812	12.329895	-0.209517	-12.5710133	11 hr	47.42899
56	-4.59	20.66210688	88.44742013	0.504882934	12.11719042	12.329895	-0.212705	-12.7622755	11 hr	47.23772
57	-4.59	20.91337758	88.42463557	0.504752873	12.11406896	12.329895	-0.215826	-12.949563	11 hr	47.05044
58	-4.59	21.15838967	88.40234802	0.50462565	12.1110156	12.329895	-0.218879	-13.132765	11 hr	46.86723
59	-4.59	21.3970419	88.38057095	0.50450134	12.10803216	12.329895	-0.221863	-13.311771	11 hr	46.68823
60	-4.59	21.62923453	88.35931782	0.504380021	12.10512051	12.329895	-0.224775	-13.4864701	11 hr	46.51353
61	-4.59	21.85486944	88.33860208	0.50426177	12.10228248	12.329895	-0.227613	-13.656752	11 hr	46.34325
62	-4.59	22.07385031	88.31843711	0.504146663	12.0995199	12.329895	-0.230375	-13.8225067	11 hr	46.17749
63	-4.59	22.28608263	88.29883622	0.504034775	12.0968346	12.329895	-0.23306	-13.9836246	11 hr	46.01638
64	-4.59	22.4914739	88.27981262	0.503926183	12.09422839	12.329895	-0.235667	-14.1399972	11 hr	45.86
65	-4.59	22.6899337	88.26137938	0.503820961	12.09170306	12.329895	-0.238192	-14.2915171	11 hr	45.70848
66	-4.59	22.8813738	88.24354941	0.503719182	12.08926038	12.329895	-0.240635	-14.4380781	11 hr	45.56192
67	-4.59	23.0657083	88.22633545	0.50362092	12.08690209	12.329895	-0.242993	-14.5795756	11 hr	45.42042
68	-4.59	23.24285371	88.20975	0.503526246	12.0846299	12.329895	-0.245265	-14.7159068	11 hr	45.28409
69	-4.59	23.4127291	88.19380533	0.503435229	12.0824455	12.329895	-0.24745	-14.8469709	11 hr	45.15303
70	-4.59	23.57525619	88.1785134	0.503347938	12.08035052	12.329895	-0.249544	-14.9726694	11 hr	45.02733
71	-4.59	23.73035947	88.16388591	0.503264441	12.07834657	12.329895	-0.251548	-15.0929064	11 hr	44.90709
72	-4.59	23.8779663	88.14993419	0.5031848	12.0764352	12.329895	-0.25346	-15.2075885	11 hr	44.79241
73	-4.59	24.01800702	88.1366692	0.50310908	12.07461792	12.329895	-0.255277	-15.3166257	11 hr	44.68337
74	-4.59	24.15041507	88.12410154	0.50303734	12.07289616	12.329895	-0.256999	-15.419931	11 hr	44.58007

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									Hours	Min.

75	-4.59	24.27512709	88.11224135	0.502969639	12.07127133	12.329895	-0.258624	-15.5174209	11 hr	44.48258
76	-4.59	24.39208299	88.10109833	0.502906031	12.06974475	12.329895	-0.26015	-15.6090158	11 hr	44.39098
77	-4.59	24.50122608	88.09068169	0.50284657	12.06831768	12.329895	-0.261577	-15.6946397	11 hr	44.30536
78	-4.59	24.60250317	88.08100016	0.502791305	12.06699132	12.329895	-0.262904	-15.7742213	11 hr	44.22578
79	-4.59	24.69586459	88.07206189	0.502740283	12.06576679	12.329895	-0.264128	-15.8476932	11 hr	44.15231
80	-4.59	24.78126436	88.06387452	0.502693547	12.06464513	12.329895	-0.26525	-15.9149928	11 hr	44.08501
81	-4.59	24.85866022	88.05644508	0.502651138	12.06362731	12.329895	-0.266268	-15.9760623	11 hr	44.02394
82	-4.59	24.92801369	88.04978001	0.502613092	12.0627142	12.329895	-0.267181	-16.0308487	11 hr	43.96915
83	-4.59	24.98929018	88.04388513	0.502579442	12.06190661	12.329895	-0.267988	-16.0793042	11 hr	43.9207
84	-4.59	25.04245901	88.03876561	0.502550218	12.06120524	12.329895	-0.26869	-16.1213862	11 hr	43.87861
85	-4.59	25.08749348	88.03442597	0.502525447	12.06061072	12.329895	-0.269284	-16.1570578	11 hr	43.84294
86	-4.59	25.12437093	88.03087006	0.502505148	12.06012356	12.329895	-0.269771	-16.1862871	11 hr	43.81371
87	-4.59	25.15307274	88.02810106	0.502489342	12.05974421	12.329895	-0.270151	-16.2090481	11 hr	43.79095
88	-4.59	25.17358442	88.02612142	0.502478042	12.059473	12.329895	-0.270422	-16.2253206	11 hr	43.77468
89	-4.59	25.18589559	88.02493293	0.502471258	12.05931018	12.329895	-0.270585	-16.2350899	11 hr	43.76491
90	-4.59	25.19	88.02453664	0.502468995	12.05925589	12.329895	-0.270639	-16.2383473	11 hr	43.76165
91	-4.59	25.18589559	88.02493293	0.502471258	12.05931018	12.329895	-0.270585	-16.2350899	11 hr	43.76491
92	-4.59	25.17358442	88.02612142	0.502478042	12.059473	12.329895	-0.270422	-16.2253206	11 hr	43.77468
93	-4.59	25.15307274	88.02810106	0.502489342	12.05974421	12.329895	-0.270151	-16.2090481	11 hr	43.79095
94	-4.59	25.12437093	88.03087006	0.502505148	12.06012356	12.329895	-0.269771	-16.1862871	11 hr	43.81371
95	-4.59	25.08749348	88.03442597	0.502525447	12.06061072	12.329895	-0.269284	-16.1570578	11 hr	43.84294
96	-4.59	25.04245901	88.03876561	0.502550218	12.06120524	12.329895	-0.26869	-16.1213862	11 hr	43.87861
97	-4.59	24.98929018	88.04388513	0.502579442	12.06190661	12.329895	-0.267988	-16.0793042	11 hr	43.9207
98	-4.59	24.92801369	88.04978001	0.502613092	12.0627142	12.329895	-0.267181	-16.0308487	11 hr	43.96915
99	-4.59	24.85866022	88.05644508	0.502651138	12.06362731	12.329895	-0.266268	-15.9760623	11 hr	44.02394

λ_{sun} (0 for spring in northern hemisphere) This is Ls	Latitude (phi)	$\delta_{degrees} =$ $\arcsin((\sin(25.19) * \sin(\lambda_{sun}))$	$H = \arccos((\sin(-.17) -$ $\sin(lw) * \sin(\delta)) / (\cos(lw) *$ $\cos(\delta)))$	Day Length = $2 * 1.027491 * H / 360$	Daylight In Hours David's Calculation (=E value * 24)	Half Sol in Hours	Difference Half day - Daylight (G-F)	Minutes above or below 12 hours for daylight	Hours + minutes of daylight	
									Hours	Min.

100	-4.59	24.78126436	88.06387452	0.502693547	12.06464513	12.329895	-0.26525	-15.9149928	11 hr	44.08501
101	-4.59	24.69586459	88.07206189	0.502740283	12.06576679	12.329895	-0.264128	-15.8476932	11 hr	44.15231
102	-4.59	24.60250317	88.08100016	0.502791305	12.06699132	12.329895	-0.262904	-15.7742213	11 hr	44.22578
103	-4.59	24.50122608	88.09068169	0.50284657	12.06831768	12.329895	-0.261577	-15.6946397	11 hr	44.30536
104	-4.59	24.39208299	88.10109833	0.502906031	12.06974475	12.329895	-0.26015	-15.6090158	11 hr	44.39098
105	-4.59	24.27512709	88.11224135	0.502969639	12.07127133	12.329895	-0.258624	-15.5174209	11 hr	44.48258
106	-4.59	24.15041507	88.12410154	0.50303734	12.07289616	12.329895	-0.256999	-15.419931	11 hr	44.58007
107	-4.59	24.01800702	88.1366692	0.50310908	12.07461792	12.329895	-0.255277	-15.3166257	11 hr	44.68337
108	-4.59	23.8779663	88.14993419	0.5031848	12.0764352	12.329895	-0.25346	-15.2075885	11 hr	44.79241
109	-4.59	23.73035947	88.16388591	0.503264441	12.07834657	12.329895	-0.251548	-15.0929064	11 hr	44.90709
110	-4.59	23.57525619	88.1785134	0.503347938	12.08035052	12.329895	-0.249544	-14.9726694	11 hr	45.02733
111	-4.59	23.4127291	88.19380533	0.503435229	12.0824455	12.329895	-0.24745	-14.8469709	11 hr	45.15303
112	-4.59	23.24285371	88.20975	0.503526246	12.0846299	12.329895	-0.245265	-14.7159068	11 hr	45.28409
113	-4.59	23.0657083	88.22633545	0.50362092	12.08690209	12.329895	-0.242993	-14.5795756	11 hr	45.42042
114	-4.59	22.8813738	88.24354941	0.503719182	12.08926038	12.329895	-0.240635	-14.4380781	11 hr	45.56192
115	-4.59	22.6899337	88.26137938	0.503820961	12.09170306	12.329895	-0.238192	-14.2915171	11 hr	45.70848
116	-4.59	22.4914739	88.27981262	0.503926183	12.09422839	12.329895	-0.235667	-14.1399972	11 hr	45.86
117	-4.59	22.28608263	88.29883622	0.504034775	12.0968346	12.329895	-0.23306	-13.9836246	11 hr	46.01638
118	-4.59	22.07385031	88.31843711	0.504146663	12.0995199	12.329895	-0.230375	-13.8225067	11 hr	46.17749
119	-4.59	21.85486944	88.33860208	0.50426177	12.10228248	12.329895	-0.227613	-13.656752	11 hr	46.34325
120	-4.59	21.62923453	88.35931782	0.504380021	12.10512051	12.329895	-0.224775	-13.4864701	11 hr	46.51353
121	-4.59	21.3970419	88.38057095	0.50450134	12.10803216	12.329895	-0.221863	-13.311771	11 hr	46.68823
122	-4.59	21.15838967	88.40234802	0.50462565	12.1110156	12.329895	-0.218879	-13.132765	11 hr	46.86723
123	-4.59	20.91337758	88.42463557	0.504752873	12.11406896	12.329895	-0.215826	-12.949563	11 hr	47.05044
124	-4.59	20.66210688	88.44742013	0.504882934	12.11719042	12.329895	-0.212705	-12.7622755	11 hr	47.23772

λ_{sun} (0 for spring in northern hemisphere) This is Ls	Latitude (phi)	$\delta_{degrees} =$ $\arcsin((\sin(25.19) * \sin(\lambda_{sun}))$	$H = \arccos((\sin(-1.7) -$ $\sin(lw) * \sin(\delta)) / (\cos(lw) *$ $\cos(\delta)))$	Day Length = $2 * 1.027491 * H / 360$	Daylight In Hours David's Calculation (=E value * 24)	Half Sol in Hours	Difference Half day - Daylight (G-F)	Minutes above or below 12 hours for daylight	Hours + minutes of daylight	
									Hours	Min.

125	-4.59	20.4046803	88.47068824	0.505015755	12.12037812	12.329895	-0.209517	-12.5710133	11 hr	47.42899
126	-4.59	20.14120185	88.49442652	0.50515126	12.12363024	12.329895	-0.206265	-12.3758864	11 hr	47.62411
127	-4.59	19.87177679	88.5186216	0.505289372	12.12694494	12.329895	-0.20295	-12.1770045	11 hr	47.823
128	-4.59	19.59651149	88.54326023	0.505430017	12.1303204	12.329895	-0.199575	-11.9744768	11 hr	48.02552
129	-4.59	19.31551336	88.56832925	0.505573118	12.13375483	12.329895	-0.19614	-11.7684112	11 hr	48.23159
130	-4.59	19.02889074	88.59381562	0.505718601	12.13724643	12.329895	-0.192649	-11.5589151	11 hr	48.44108
131	-4.59	18.73675284	88.61970643	0.505866393	12.14079344	12.329895	-0.189102	-11.3460945	11 hr	48.65391
132	-4.59	18.43920959	88.64598892	0.506016421	12.14439411	12.329895	-0.185501	-11.1300544	11 hr	48.86995
133	-4.59	18.13637166	88.67265049	0.506168613	12.14804671	12.329895	-0.181848	-10.9108982	11 hr	49.0891
134	-4.59	17.82835026	88.69967872	0.506322898	12.15174955	12.329895	-0.178145	-10.688728	11 hr	49.31127
135	-4.59	17.51525716	88.72706138	0.506479206	12.15550094	12.329895	-0.174394	-10.4636445	11 hr	49.53636
136	-4.59	17.19720459	88.75478643	0.506637468	12.15929924	12.329895	-0.170596	-10.2357466	11 hr	49.76425
137	-4.59	16.87430512	88.78284203	0.506797617	12.16314282	12.329895	-0.166752	-10.0051316	11 hr	49.99487
138	-4.59	16.54667169	88.81121657	0.506959587	12.1670301	12.329895	-0.162865	-9.77189496	11 hr	50.22811
139	-4.59	16.21441747	88.83989864	0.507123313	12.17095951	12.329895	-0.158936	-9.5361304	11 hr	50.46387
140	-4.59	15.87765582	88.86887707	0.50728873	12.17492952	12.329895	-0.154965	-9.29792978	11 hr	50.70207
141	-4.59	15.53650028	88.89814092	0.507455776	12.17893863	12.329895	-0.150956	-9.05738304	11 hr	50.94262
142	-4.59	15.19106443	88.92767948	0.507624391	12.18298538	12.329895	-0.14691	-8.81457822	11 hr	51.18542
143	-4.59	14.84146195	88.95748228	0.507794513	12.18706832	12.329895	-0.142827	-8.56960138	11 hr	51.4304
144	-4.59	14.48780649	88.98753908	0.507966086	12.19118607	12.329895	-0.138709	-8.32253663	11 hr	51.67746
145	-4.59	14.13021166	89.0178399	0.508139052	12.19533724	12.329895	-0.134558	-8.07346609	11 hr	51.92653
146	-4.59	13.76879101	89.04837498	0.508313355	12.19952051	12.329895	-0.130374	-7.82246991	11 hr	52.17753
147	-4.59	13.40365796	89.07913482	0.508488941	12.20373458	12.329895	-0.12616	-7.56962624	11 hr	52.43037
148	-4.59	13.0349258	89.11011015	0.508665757	12.20797816	12.329895	-0.121917	-7.31501128	11 hr	52.68499
149	-4.59	12.66270765	89.14129193	0.508843751	12.21225002	12.329895	-0.117645	-7.05869928	11 hr	52.9413

λ_{sun} (0 for spring in northern hemisphere) This is Ls	Latitude (phi)	$\delta_{degrees} =$ $\arcsin((\sin(25.19) * \sin(\lambda_{sun}))$	$H = \arccos((\sin(-.17) -$ $\sin(lw) * \sin(\delta)) / (\cos(lw) *$ $\cos(\delta)))$	Day Length = $2 * 1.027491 * H / 360$	Daylight In Hours David's Calculation (=E value * 24)	Half Sol in Hours	Difference Half day - Daylight (G-F)	Minutes above or below 12 hours for daylight	Hours + minutes of daylight	
									Hours	Min.

150	-4.59	12.28711642	89.17267137	0.509022874	12.21654897	12.329895	-0.113346	-6.80076253	11 hr	53.19924
151	-4.59	11.90826481	89.20423991	0.509203076	12.22087382	12.329895	-0.109021	-6.54127143	11 hr	53.45873
152	-4.59	11.52626529	89.2359892	0.50938431	12.22522344	12.329895	-0.104672	-6.2802945	11 hr	53.71971
153	-4.59	11.14123007	89.26791115	0.509566529	12.22959671	12.329895	-0.100298	-6.01789839	11 hr	53.9821
154	-4.59	10.75327109	89.29999786	0.509749689	12.23399255	12.329895	-0.095902	-5.75414796	11 hr	54.24585
155	-4.59	10.3625	89.33224165	0.509933746	12.23840991	12.329895	-0.091485	-5.48910631	11 hr	54.51089
156	-4.59	9.969028179	89.36463506	0.510118657	12.24284777	12.329895	-0.087047	-5.22283479	11 hr	54.77717
157	-4.59	9.572966702	89.39717083	0.51030438	12.24730513	12.329895	-0.08259	-4.95539311	11 hr	55.04461
158	-4.59	9.17442634	89.42984189	0.510490876	12.25178102	12.329895	-0.078114	-4.68683933	11 hr	55.31316
159	-4.59	8.773517562	89.46264138	0.510678105	12.25627451	12.329895	-0.07362	-4.41722994	11 hr	55.58277
160	-4.59	8.370350533	89.49556259	0.510866028	12.26078468	12.329895	-0.06911	-4.14661995	11 hr	55.85338
161	-4.59	7.965035114	89.52859902	0.51105461	12.26531063	12.329895	-0.064584	-3.87506286	11 hr	56.12494
162	-4.59	7.557680868	89.56174433	0.511243812	12.2698515	12.329895	-0.060044	-3.60261083	11 hr	56.39739
163	-4.59	7.148397059	89.59499233	0.511433601	12.27440643	12.329895	-0.055489	-3.32931467	11 hr	56.67069
164	-4.59	6.737292666	89.62833699	0.511623942	12.27897461	12.329895	-0.05092	-3.05522391	11 hr	56.94478
165	-4.59	6.324476385	89.66177244	0.511814801	12.28355523	12.329895	-0.04634	-2.78038691	11 hr	57.21961
166	-4.59	5.910056641	89.69529294	0.512006146	12.2881475	12.329895	-0.041748	-2.50485086	11 hr	57.49515
167	-4.59	5.494141598	89.72889286	0.512197944	12.29275065	12.329895	-0.037144	-2.22866191	11 hr	57.77134
168	-4.59	5.076839171	89.76256672	0.512390164	12.29736393	12.329895	-0.032531	-1.95186522	11 hr	58.04813
169	-4.59	4.658257039	89.79630913	0.512582775	12.3019866	12.329895	-0.027908	-1.67450502	11 hr	58.32549
170	-4.59	4.23850266	89.83011482	0.512775747	12.30661793	12.329895	-0.023277	-1.39662469	11 hr	58.60338
171	-4.59	3.817683284	89.86397861	0.512969051	12.31125723	12.329895	-0.018638	-1.11826682	11 hr	58.88173
172	-4.59	3.395905971	89.89789539	0.513162658	12.31590379	12.329895	-0.013991	-0.83947332	11 hr	59.16053
173	-4.59	2.973277609	89.93186014	0.513356538	12.32055692	12.329895	-0.009338	-0.56028545	11 hr	59.43971
174	-4.59	2.549904928	89.96586793	0.513550664	12.32521595	12.329895	-0.004679	-0.28074393	11 hr	59.71926

λ_{sun} (0 for spring in northern hemisphere) This is Ls	Latitude (phi)	$\delta_{degrees} =$ $\arcsin((\sin(25.19) * \sin(\lambda_{sun}))$	$H = \arccos((\sin(-17) -$ $\sin(lw) * \sin(\delta)) / (\cos(lw) *$ $\cos(\delta)))$	Day Length = $2 * 1.027491 * H / 360$	Daylight In Hours David's Calculation (=E value * 24)	Half Sol in Hours	Difference Half day - Daylight (G-F)	Minutes above or below 12 hours for daylight	Hours + minutes of daylight	
									Hours	Min.

175	-4.59	2.125894518	89.99991384	0.513745008	12.3298802	12.329895	-1.48E-05	-0.00088898	12 hr	59.99911
176	-4.59	1.701352853	90.03399304	0.513939542	12.33454901	12.329895	0.004654	0.27923957	12 hr	0.27924
177	-4.59	1.276386306	90.06810071	0.514134238	12.33922172	12.329895	0.009327	0.55960221	12 hr	0.559602
178	-4.59	0.851101167	90.10223209	0.51432907	12.34389767	12.329895	0.014003	0.8401597	12 hr	0.84016
179	-4.59	0.425603669	90.13638243	0.51452401	12.34857623	12.329895	0.018681	1.12087298	12 hr	1.120873
180	-4.59	2.98768E-15	90.17054697	0.51471903	12.35325673	12.329895	0.023362	1.40170306	12 hr	1.401703
181	-4.59	-0.425603669	90.20472098	0.514914105	12.35793853	12.329895	0.028044	1.68261099	12 hr	1.682611
182	-4.59	-0.851101167	90.23889972	0.515109207	12.36262098	12.329895	0.032726	1.96355777	12 hr	1.963558
183	-4.59	-1.276386306	90.27307843	0.515304309	12.36730342	12.329895	0.037408	2.24450426	12 hr	2.244504
184	-4.59	-1.701352853	90.30725231	0.515499383	12.3719852	12.329895	0.04209	2.52541109	12 hr	2.525411
185	-4.59	-2.125894518	90.34141654	0.515694402	12.37666566	12.329895	0.046771	2.80623864	12 hr	2.806239
186	-4.59	-2.549904928	90.37556626	0.515889339	12.38134413	12.329895	0.051449	3.0869469	12 hr	3.086947
187	-4.59	-2.973277609	90.40969655	0.516084164	12.38601994	12.329895	0.056125	3.36749541	12 hr	3.367495
188	-4.59	-3.395905971	90.44380242	0.51627885	12.3906924	12.329895	0.060797	3.64784323	12 hr	3.647843
189	-4.59	-3.817683284	90.47787882	0.516473368	12.39536083	12.329895	0.065466	3.92794877	12 hr	3.927949
190	-4.59	-4.23850266	90.51192061	0.516667688	12.40002451	12.329895	0.070129	4.20776983	12 hr	4.20777
191	-4.59	-4.658257039	90.54592256	0.516861781	12.40468274	12.329895	0.074788	4.4872634	12 hr	4.487263
192	-4.59	-5.076839171	90.57987934	0.517055616	12.40933477	12.329895	0.07944	4.7663857	12 hr	4.766386
193	-4.59	-5.494141598	90.61378552	0.517249162	12.41397988	12.329895	0.084085	5.04509203	12 hr	5.045092
194	-4.59	-5.910056641	90.64763553	0.517442387	12.41861729	12.329895	0.088722	5.3233367	12 hr	5.323337
195	-4.59	-6.324476385	90.6814237	0.51763526	12.42324623	12.329895	0.093351	5.60107301	12 hr	5.601073
196	-4.59	-6.737292666	90.7151442	0.517827746	12.4278659	12.329895	0.097971	5.87825312	12 hr	5.878253
197	-4.59	-7.148397059	90.74879108	0.518019812	12.43247548	12.329895	0.10258	6.15482801	12 hr	6.154828
198	-4.59	-7.557680868	90.78235821	0.518211422	12.43707414	12.329895	0.107179	6.43074738	12 hr	6.430747
199	-4.59	-7.965035114	90.81583931	0.518402542	12.44166101	12.329895	0.111766	6.70595964	12 hr	6.70596

λ_{sun} (0 for spring in northern hemisphere) This is Ls	Latitude (phi)	$\delta_{degrees} =$ $\arcsin((\sin(25.19) * \sin(\lambda_{sun}))$	$H = \arccos((\sin(-.17) -$ $\sin(lw) * \sin(\delta)) / (\cos(lw) *$ $\cos(\delta)))$	Day Length = $2 * 1.027491 * H / 360$	Daylight In Hours David's Calculation (=E value * 24)	Half Sol in Hours	Difference Half day - Daylight (G-F)	Minutes above or below 12 hours for daylight	Hours + minutes of daylight	
									Hours	Min.

200	-4.59	-8.370350533	90.84922794	0.518593134	12.44623521	12.329895	0.11634	6.98041177	12 hr	6.980412
201	-4.59	-8.773517562	90.88251747	0.51878316	12.45079583	12.329895	0.120901	7.2540493	12 hr	7.254049
202	-4.59	-9.17442634	90.91570108	0.518972581	12.45534195	12.329895	0.125447	7.52681622	12 hr	7.526816
203	-4.59	-9.572966702	90.94877178	0.519161358	12.45987259	12.329895	0.129978	7.79865495	12 hr	7.798655
204	-4.59	-9.969028179	90.98172234	0.519349449	12.46438678	12.329895	0.134492	8.06950623	12 hr	8.069506
205	-4.59	-10.3625	91.01454537	0.519536812	12.4688835	12.329895	0.138988	8.33930913	12 hr	8.339309
206	-4.59	-10.75327109	91.04723322	0.519723404	12.47336169	12.329895	0.143467	8.60800091	12 hr	8.608001
207	-4.59	-11.14123007	91.07977805	0.519909179	12.4778203	12.329895	0.147925	8.87551704	12 hr	8.875517
208	-4.59	-11.52626529	91.11217177	0.520094092	12.4822582	12.329895	0.152363	9.14179113	12 hr	9.141791
209	-4.59	-11.90826481	91.14440608	0.520278094	12.48667426	12.329895	0.156779	9.40675484	12 hr	9.406755
210	-4.59	-12.28711642	91.17647243	0.520461138	12.49106731	12.329895	0.161172	9.67033791	12 hr	9.670338
211	-4.59	-12.66270765	91.20836202	0.520643173	12.49543615	12.329895	0.165541	9.93246807	12 hr	9.932468
212	-4.59	-13.0349258	91.24006582	0.520824147	12.49977953	12.329895	0.169885	10.193071	12 hr	10.19307
213	-4.59	-13.40365796	91.27157453	0.521004008	12.50409619	12.329895	0.174201	10.4520704	12 hr	10.45207
214	-4.59	-13.76879101	91.30287862	0.5211827	12.50838481	12.329895	0.17849	10.7093877	12 hr	10.70939
215	-4.59	-14.13021166	91.33396827	0.521360169	12.51264405	12.329895	0.182749	10.9649424	12 hr	10.96494
216	-4.59	-14.48780649	91.36483344	0.521536356	12.51687254	12.329895	0.186978	11.2186518	12 hr	11.21865
217	-4.59	-14.84146195	91.3954638	0.521711203	12.52106887	12.329895	0.191174	11.4704312	12 hr	11.47043
218	-4.59	-15.19106443	91.42584877	0.521884649	12.52523157	12.329895	0.195337	11.7201935	12 hr	11.72019
219	-4.59	-15.53650028	91.45597753	0.522056632	12.52935917	12.329895	0.199464	11.9678497	12 hr	11.96785
220	-4.59	-15.87765582	91.48583897	0.52222709	12.53345016	12.329895	0.203555	12.2133086	12 hr	12.21331
221	-4.59	-16.21441747	91.51542175	0.522395957	12.53750296	12.329895	0.207608	12.456477	12 hr	12.45648
222	-4.59	-16.54667169	91.54471427	0.522563167	12.541516	12.329895	0.211621	12.6972593	12 hr	12.69726
223	-4.59	-16.87430512	91.57370467	0.522728652	12.54548765	12.329895	0.215593	12.9355583	12 hr	12.93556
224	-4.59	-17.19720459	91.60238085	0.522892344	12.54941625	12.329895	0.219521	13.1712745	12 hr	13.17127

λ_{sun} (0 for spring in northern hemisphere) This is Ls	Latitude (phi)	$\delta_{degrees} =$ $\arcsin((\sin(25.19) * \sin(\lambda_{sun}))$	$H = \arccos((\sin(-.17) -$ $\sin(lw) * \sin(\delta)) / (\cos(lw) *$ $\cos(\delta)))$	Day Length = $2 * 1.027491 * H / 360$	Daylight In Hours David's Calculation (=E value * 24)	Half Sol in Hours	Difference Half day - Daylight (G-F)	Minutes above or below 12 hours for daylight	Hours + minutes of daylight	
									Hours	Min.

225	-4.59	-17.51525716	91.6307305	0.523054172	12.55330012	12.329895	0.223405	13.4043066	12 hr	13.40431
226	-4.59	-17.82835026	91.65874105	0.523214064	12.55713753	12.329895	0.227243	13.6345513	12 hr	13.63455
227	-4.59	-18.13637166	91.68639972	0.523371947	12.56092674	12.329895	0.231032	13.8619035	12 hr	13.8619
228	-4.59	-18.43920959	91.71369352	0.523527748	12.56466596	12.329895	0.234771	14.0862566	12 hr	14.08626
229	-4.59	-18.73675284	91.74060925	0.523681391	12.56835338	12.329895	0.238458	14.3075019	12 hr	14.3075
230	-4.59	-19.02889074	91.76713353	0.523832799	12.57198717	12.329895	0.242092	14.5255296	12 hr	14.52553
231	-4.59	-19.31551336	91.79325281	0.523981895	12.57556548	12.329895	0.24567	14.7402282	12 hr	14.74023
232	-4.59	-19.59651149	91.81895336	0.524128601	12.57908643	12.329895	0.249191	14.9514849	12 hr	14.95148
233	-4.59	-19.87177679	91.84422133	0.524272838	12.58254811	12.329895	0.252653	15.1591858	12 hr	15.15919
234	-4.59	-20.14120185	91.86904273	0.524414525	12.58594861	12.329895	0.256054	15.3632159	12 hr	15.36322
235	-4.59	-20.4046803	91.89340345	0.524553583	12.589286	12.329895	0.259391	15.5634593	12 hr	15.56346
236	-4.59	-20.66210688	91.91728931	0.524689931	12.59255833	12.329895	0.262663	15.7597993	12 hr	15.7598
237	-4.59	-20.91337758	91.94068604	0.524823486	12.59576366	12.329895	0.265869	15.9521188	12 hr	15.95212
238	-4.59	-21.15838967	91.96357934	0.524954167	12.59890001	12.329895	0.269005	16.1403001	12 hr	16.1403
239	-4.59	-21.3970419	91.98595489	0.525081893	12.60196544	12.329895	0.27207	16.3242254	12 hr	16.32423
240	-4.59	-21.62923453	92.00779835	0.525206582	12.60495796	12.329895	0.275063	16.5037771	12 hr	16.50378
241	-4.59	-21.85486944	92.02909542	0.525328152	12.60787564	12.329895	0.277981	16.6788375	12 hr	16.67884
242	-4.59	-22.07385031	92.04983186	0.525446521	12.6107165	12.329895	0.280821	16.8492895	12 hr	16.84929
243	-4.59	-22.28608263	92.06999349	0.525561609	12.61347862	12.329895	0.283584	17.0150167	12 hr	17.01502
244	-4.59	-22.4914739	92.08956627	0.525673336	12.61616007	12.329895	0.286265	17.1759035	12 hr	17.1759
245	-4.59	-22.6899337	92.10853627	0.525781622	12.61875894	12.329895	0.288864	17.3318356	12 hr	17.33184
246	-4.59	-22.8813738	92.12688974	0.525886389	12.62127334	12.329895	0.291378	17.4826998	12 hr	17.4827
247	-4.59	-23.0657083	92.14461314	0.525987559	12.62370143	12.329895	0.293806	17.6283848	12 hr	17.62838
248	-4.59	-23.24285371	92.16169313	0.526085057	12.62604137	12.329895	0.296146	17.7687812	12 hr	17.76878
249	-4.59	-23.4127291	92.17811668	0.526178807	12.62829137	12.329895	0.298396	17.9037815	12 hr	17.90378

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									Hours	Min.

250	-4.59	-23.57525619	92.19387101	0.526268737	12.6304497	12.329895	0.300555	18.033281	12 hr	18.03328
251	-4.59	-23.73035947	92.20894369	0.526354776	12.63251463	12.329895	0.30262	18.1571773	12 hr	18.15718
252	-4.59	-23.87796663	92.22332264	0.526436856	12.63448453	12.329895	0.30459	18.2753712	12 hr	18.27537
253	-4.59	-24.01800702	92.23699616	0.526514908	12.63635779	12.329895	0.306463	18.3877667	12 hr	18.38777
254	-4.59	-24.15041507	92.24995301	0.526588869	12.63813286	12.329895	0.308238	18.494271	12 hr	18.49427
255	-4.59	-24.27512709	92.26218235	0.526658678	12.63980827	12.329895	0.309913	18.5947953	12 hr	18.5948
256	-4.59	-24.39208299	92.27367385	0.526724275	12.64138259	12.329895	0.311488	18.6892546	12 hr	18.68925
257	-4.59	-24.50122608	92.2844177	0.526785603	12.64285448	12.329895	0.312959	18.7775683	12 hr	18.77757
258	-4.59	-24.60250317	92.29440462	0.526842612	12.64422268	12.329895	0.314328	18.85966	12 hr	18.85966
259	-4.59	-24.69586459	92.30362588	0.526895249	12.64548598	12.329895	0.315591	18.9354581	12 hr	18.93546
260	-4.59	-24.78126436	92.31207337	0.52694347	12.64664328	12.329895	0.316748	19.0048959	12 hr	19.0049
261	-4.59	-24.85866022	92.3197396	0.526987231	12.64769354	12.329895	0.317799	19.0679117	12 hr	19.06791
262	-4.59	-24.92801369	92.32661769	0.527026493	12.64863583	12.329895	0.318741	19.1244491	12 hr	19.12445
263	-4.59	-24.98929018	92.33270145	0.527061221	12.6494693	12.329895	0.319574	19.1744572	12 hr	19.17446
264	-4.59	-25.04245901	92.33798536	0.527091383	12.65019319	12.329895	0.320298	19.2178906	12 hr	19.21789
265	-4.59	-25.08749348	92.34246461	0.527116952	12.65080684	12.329895	0.320912	19.2547097	12 hr	19.25471
266	-4.59	-25.12437093	92.34613509	0.527137904	12.65130969	12.329895	0.321415	19.2848808	12 hr	19.28488
267	-4.59	-25.15307274	92.34899343	0.52715422	12.65170128	12.329895	0.321806	19.3083761	12 hr	19.30838
268	-4.59	-25.17358442	92.35103699	0.527165885	12.65198125	12.329895	0.322086	19.325174	12 hr	19.32517
269	-4.59	-25.18589559	92.35226389	0.527172889	12.65214933	12.329895	0.322254	19.335259	12 hr	19.33526
270	-4.59	-25.19	92.35267298	0.527175224	12.65220537	12.329895	0.32231	19.3386217	12 hr	19.33862
271	-4.59	-25.18589559	92.35226389	0.527172889	12.65214933	12.329895	0.322254	19.335259	12 hr	19.33526
272	-4.59	-25.17358442	92.35103699	0.527165885	12.65198125	12.329895	0.322086	19.325174	12 hr	19.32517
273	-4.59	-25.15307274	92.34899343	0.52715422	12.65170128	12.329895	0.321806	19.3083761	12 hr	19.30838
274	-4.59	-25.12437093	92.34613509	0.527137904	12.65130969	12.329895	0.321415	19.2848808	12 hr	19.28488

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									Hours	Min.

275	-4.59	-25.08749348	92.34246461	0.527116952	12.65080684	12.329895	0.320912	19.2547097	12 hr	19.25471
276	-4.59	-25.04245901	92.33798536	0.527091383	12.65019319	12.329895	0.320298	19.2178906	12 hr	19.21789
277	-4.59	-24.98929018	92.33270145	0.527061221	12.6494693	12.329895	0.319574	19.1744572	12 hr	19.17446
278	-4.59	-24.92801369	92.32661769	0.527026493	12.64863583	12.329895	0.318741	19.1244491	12 hr	19.12445
279	-4.59	-24.85866022	92.3197396	0.526987231	12.64769354	12.329895	0.317799	19.0679117	12 hr	19.06791
280	-4.59	-24.78126436	92.31207337	0.52694347	12.64664328	12.329895	0.316748	19.0048959	12 hr	19.0049
281	-4.59	-24.69586459	92.30362588	0.526895249	12.64548598	12.329895	0.315591	18.9354581	12 hr	18.93546
282	-4.59	-24.60250317	92.29440462	0.526842612	12.64422268	12.329895	0.314328	18.85966	12 hr	18.85966
283	-4.59	-24.50122608	92.2844177	0.526785603	12.64285448	12.329895	0.312959	18.7775683	12 hr	18.77757
284	-4.59	-24.39208299	92.27367385	0.526724275	12.64138259	12.329895	0.311488	18.6892546	12 hr	18.68925
285	-4.59	-24.27512709	92.26218235	0.526658678	12.63980827	12.329895	0.309913	18.5947953	12 hr	18.5948
286	-4.59	-24.15041507	92.24995301	0.526588869	12.63813286	12.329895	0.308238	18.494271	12 hr	18.49427
287	-4.59	-24.01800702	92.23699616	0.526514908	12.63635779	12.329895	0.306463	18.3877667	12 hr	18.38777
288	-4.59	-23.8779663	92.22332264	0.526436856	12.63448453	12.329895	0.30459	18.2753712	12 hr	18.27537
289	-4.59	-23.73035947	92.20894369	0.526354776	12.63251463	12.329895	0.30262	18.1571773	12 hr	18.15718
290	-4.59	-23.57525619	92.19387101	0.526268737	12.6304497	12.329895	0.300555	18.033281	12 hr	18.03328
291	-4.59	-23.4127291	92.17811668	0.526178807	12.62829137	12.329895	0.298396	17.9037815	12 hr	17.90378
292	-4.59	-23.24285371	92.16169313	0.526085057	12.62604137	12.329895	0.296146	17.7687812	12 hr	17.76878
293	-4.59	-23.0657083	92.14461314	0.525987559	12.62370143	12.329895	0.293806	17.6283848	12 hr	17.62838
294	-4.59	-22.8813738	92.12688974	0.525886389	12.62127334	12.329895	0.291378	17.4826998	12 hr	17.4827
295	-4.59	-22.6899337	92.10853627	0.525781622	12.61875894	12.329895	0.288864	17.3318356	12 hr	17.33184
296	-4.59	-22.4914739	92.08956627	0.525673336	12.61616007	12.329895	0.286265	17.1759035	12 hr	17.1759
297	-4.59	-22.28608263	92.06999349	0.525561609	12.61347862	12.329895	0.283584	17.0150167	12 hr	17.01502
298	-4.59	-22.07385031	92.04983186	0.525446521	12.6107165	12.329895	0.280821	16.8492895	12 hr	16.84929
299	-4.59	-21.85486944	92.02909542	0.525328152	12.60787564	12.329895	0.277981	16.6788375	12 hr	16.67884

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									Hours	Min.

300	-4.59	-21.62923453	92.00779835	0.525206582	12.60495796	12.329895	0.275063	16.5037771	12 hr	16.50378
301	-4.59	-21.3970419	91.98595489	0.525081893	12.60196544	12.329895	0.27207	16.3242254	12 hr	16.32423
302	-4.59	-21.15838967	91.96357934	0.524954167	12.59890001	12.329895	0.269005	16.1403001	12 hr	16.1403
303	-4.59	-20.91337758	91.94068604	0.524823486	12.59576366	12.329895	0.265869	15.9521188	12 hr	15.95212
304	-4.59	-20.66210688	91.91728931	0.524689931	12.59255833	12.329895	0.262663	15.7597993	12 hr	15.7598
305	-4.59	-20.4046803	91.89340345	0.524553583	12.589286	12.329895	0.259391	15.5634593	12 hr	15.56346
306	-4.59	-20.14120185	91.86904273	0.524414525	12.58594861	12.329895	0.256054	15.3632159	12 hr	15.36322
307	-4.59	-19.87177679	91.84422133	0.524272838	12.58254811	12.329895	0.252653	15.1591858	12 hr	15.15919
308	-4.59	-19.59651149	91.81895336	0.524128601	12.57908643	12.329895	0.249191	14.9514849	12 hr	14.95148
309	-4.59	-19.31551336	91.79325281	0.523981895	12.57556548	12.329895	0.24567	14.7402282	12 hr	14.74023
310	-4.59	-19.02889074	91.76713353	0.523832799	12.57198717	12.329895	0.242092	14.5255296	12 hr	14.52553
311	-4.59	-18.73675284	91.74060925	0.523681391	12.56835338	12.329895	0.238458	14.3075019	12 hr	14.3075
312	-4.59	-18.43920959	91.71369352	0.523527748	12.56466596	12.329895	0.234771	14.0862566	12 hr	14.08626
313	-4.59	-18.13637166	91.68639972	0.523371947	12.56092674	12.329895	0.231032	13.8619035	12 hr	13.8619
314	-4.59	-17.82835026	91.65874105	0.523214064	12.55713753	12.329895	0.227243	13.6345513	12 hr	13.63455
315	-4.59	-17.51525716	91.6307305	0.523054172	12.55330012	12.329895	0.223405	13.4043066	12 hr	13.40431
316	-4.59	-17.19720459	91.60238085	0.522892344	12.54941625	12.329895	0.219521	13.1712745	12 hr	13.17127
317	-4.59	-16.87430512	91.57370467	0.522728652	12.54548765	12.329895	0.215593	12.9355583	12 hr	12.93556
318	-4.59	-16.54667169	91.54471427	0.522563167	12.541516	12.329895	0.211621	12.6972593	12 hr	12.69726
319	-4.59	-16.21441747	91.51542175	0.522395957	12.53750296	12.329895	0.207608	12.456477	12 hr	12.45648
320	-4.59	-15.87765582	91.48583897	0.52222709	12.53345016	12.329895	0.203555	12.2133086	12 hr	12.21331
321	-4.59	-15.53650028	91.45597753	0.522056632	12.52935917	12.329895	0.199464	11.9678497	12 hr	11.96785
322	-4.59	-15.19106443	91.42584877	0.521884649	12.52523157	12.329895	0.195337	11.7201935	12 hr	11.72019
323	-4.59	-14.84146195	91.3954638	0.521711203	12.52106887	12.329895	0.191174	11.4704312	12 hr	11.47043
324	-4.59	-14.48780649	91.36483344	0.521536356	12.51687254	12.329895	0.186978	11.2186518	12 hr	11.21865

λ_{sun} (0 for spring in northern hemisphere) This is Ls	Latitude (phi)	$\delta_{degrees} =$ $\arcsin((\sin(25.19) * \sin(\lambda_{sun}))$	$H = \arccos((\sin(-.17) -$ $\sin(lw) * \sin(\delta)) / (\cos(lw) *$ $\cos(\delta)))$	Day Length = $2 * 1.027491 * H / 360$	Daylight In Hours David's Calculation (=E value * 24)	Half Sol in Hours	Difference Half day - Daylight (G-F)	Minutes above or below 12 hours for daylight	Hours + minutes of daylight	
									Hours	Min.

325	-4.59	-14.13021166	91.33396827	0.521360169	12.51264405	12.329895	0.182749	10.9649424	12 hr	10.96494
326	-4.59	-13.76879101	91.30287862	0.5211827	12.50838481	12.329895	0.17849	10.7093877	12 hr	10.70939
327	-4.59	-13.40365796	91.27157453	0.521004008	12.50409619	12.329895	0.174201	10.4520704	12 hr	10.45207
328	-4.59	-13.0349258	91.24006582	0.520824147	12.49977953	12.329895	0.169885	10.193071	12 hr	10.19307
329	-4.59	-12.66270765	91.20836202	0.520643173	12.49543615	12.329895	0.165541	9.93246807	12 hr	9.932468
330	-4.59	-12.28711642	91.17647243	0.520461138	12.49106731	12.329895	0.161172	9.67033791	12 hr	9.670338
331	-4.59	-11.90826481	91.14440608	0.520278094	12.48667426	12.329895	0.156779	9.40675484	12 hr	9.406755
332	-4.59	-11.52626529	91.11217177	0.520094092	12.4822582	12.329895	0.152363	9.14179113	12 hr	9.141791
333	-4.59	-11.14123007	91.07977805	0.519909179	12.4778203	12.329895	0.147925	8.87551704	12 hr	8.875517
334	-4.59	-10.75327109	91.04723322	0.519723404	12.47336169	12.329895	0.143467	8.60800091	12 hr	8.608001
335	-4.59	-10.3625	91.01454537	0.519536812	12.4688835	12.329895	0.138988	8.33930913	12 hr	8.339309
336	-4.59	-9.969028179	90.98172234	0.519349449	12.46438678	12.329895	0.134492	8.06950623	12 hr	8.069506
337	-4.59	-9.572966702	90.94877178	0.519161358	12.45987259	12.329895	0.129978	7.79865495	12 hr	7.798655
338	-4.59	-9.17442634	90.91570108	0.518972581	12.45534195	12.329895	0.125447	7.52681622	12 hr	7.526816
339	-4.59	-8.773517562	90.88251747	0.51878316	12.45079583	12.329895	0.120901	7.2540493	12 hr	7.254049
340	-4.59	-8.370350533	90.84922794	0.518593134	12.44623521	12.329895	0.11634	6.98041177	12 hr	6.980412
341	-4.59	-7.965035114	90.81583931	0.518402542	12.44166101	12.329895	0.111766	6.70595964	12 hr	6.70596
342	-4.59	-7.557680868	90.78235821	0.518211422	12.43707414	12.329895	0.107179	6.43074738	12 hr	6.430747
343	-4.59	-7.148397059	90.74879108	0.518019812	12.43247548	12.329895	0.10258	6.15482801	12 hr	6.154828
344	-4.59	-6.737292666	90.7151442	0.517827746	12.4278659	12.329895	0.097971	5.87825312	12 hr	5.878253
345	-4.59	-6.324476385	90.6814237	0.51763526	12.42324623	12.329895	0.093351	5.60107301	12 hr	5.601073
346	-4.59	-5.910056641	90.64763553	0.517442387	12.41861729	12.329895	0.088722	5.3233367	12 hr	5.323337
347	-4.59	-5.494141598	90.61378552	0.517249162	12.41397988	12.329895	0.084085	5.04509203	12 hr	5.045092
348	-4.59	-5.076839171	90.57987934	0.517055616	12.40933477	12.329895	0.07944	4.7663857	12 hr	4.766386
349	-4.59	-4.658257039	90.54592256	0.516861781	12.40468274	12.329895	0.074788	4.4872634	12 hr	4.487263

λ_{sun} (0 for spring in northern hemisphere) This is Ls	Latitude (phi)	$\delta_{degrees} =$ $\arcsin((\sin(25.19) * \sin(\lambda_{sun}))$	$H = \arccos((\sin(-.17) -$ $\sin(lw) * \sin(\delta)) / (\cos(lw) *$ $\cos(\delta)))$	Day Length = $2 * 1.027491 * H / 360$	Daylight In Hours David's Calculation (=E value * 24)	Half Sol in Hours	Difference Half day - Daylight (G-F)	Minutes above or below 12 hours for daylight	Hours + minutes of daylight	Hours	Min.
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350	-4.59	-4.23850266	90.51192061	0.516667688	12.40002451	12.329895	0.070129	4.20776983	12 hr	4.20777
351	-4.59	-3.817683284	90.47787882	0.516473368	12.39536083	12.329895	0.065466	3.92794877	12 hr	3.927949
352	-4.59	-3.395905971	90.44380242	0.51627885	12.3906924	12.329895	0.060797	3.64784323	12 hr	3.647843
353	-4.59	-2.973277609	90.40969655	0.516084164	12.38601994	12.329895	0.056125	3.36749541	12 hr	3.367495
354	-4.59	-2.549904928	90.37556626	0.515889339	12.38134413	12.329895	0.051449	3.0869469	12 hr	3.086947
355	-4.59	-2.125894518	90.34141654	0.515694402	12.37666566	12.329895	0.046771	2.80623864	12 hr	2.806239
356	-4.59	-1.701352853	90.30725231	0.515499383	12.3719852	12.329895	0.04209	2.52541109	12 hr	2.525411
357	-4.59	-1.276386306	90.27307843	0.515304309	12.36730342	12.329895	0.037408	2.24450426	12 hr	2.244504
358	-4.59	-0.851101167	90.23889972	0.515109207	12.36262098	12.329895	0.032726	1.96355777	12 hr	1.963558
359	-4.59	-0.425603669	90.20472098	0.514914105	12.35793853	12.329895	0.028044	1.68261099	12 hr	1.682611
360	-4.59	-5.97537E-15	90.17054697	0.51471903	12.35325673	12.329895	0.023362	1.40170306	12 hr	1.401703