A detailed description of a day's work Lars Bergman, 2021-11-29

As Frank has pointed out many a time, you should consult primary sources if you want to find out how navigation was performed yesterday. A few years ago I come across Herman Korsström's Merenkulkutaulut / Nautiska tabeller, Helsinki 1922, a bilingual Finnish/Swedish nautical table. In the book two loose papers were found, one was an Inward Clearing Bill from July 1939, identifying the vessel, and the other measuring some 21 cm x 14 cm, containing the day's work onboard the iron barque *Alastor* of Hanko, Finland, in the North Sea on 21 November 1937.

Alastor was lunched in Sunderland in 1875, sailed worldwide in her prime days, and in the thirtieth shipped split-wood from Scandinavian ports to UK. In WW2 she was taken over by the British authorities and finally became a restaurant in Ramsgate. She was broken up in 1952, 77 years old. *Alastor* carried a main skysail in her younger days and had a long jib-boom. In her later days the rigging was somewhat cut down and during her Finnish time she didn't carry any royal yards. The gross tonnage was around 860 tons and the ship's length were close to 60 meters. She was classed in Mariehamn in May 1937 and then made two more voyages to the UK that same year. The voyage when this day's work was made was possibly from Gravesend to a winter lay-up in the Baltic Sea, possibly in Oskarshamn on the east coast of Sweden. I have not been able to trace down the history of *Alastor* more than that for 1937.

The paper found contains a lot of information of a typical day's work to ascertain the noon position. Around 10 a.m. local time three sights of the Sun's LL were taken. These observations were recorded elsewhere and not reduced until the noon latitude was obtained. The sums of the a.m. chronometer times and sextant readings are however shown, and this makes it possible to guestimate the readings. One possible set, of many, is

Chronometer time	$9^h\ 43^m\ 33^s$	sextant reading	11° 57′ 0″
	9 44 45		12 1 0
	9 46 1		12 5 30
	133 79		35 63.5

Being late autumn in the North Sea, the azimuth of the sun was around south southeast at that time of the day.

I have numbered the different lines in the paper in order to be easily referenced, the numbering is however not in the order of evaluation. Extracts from NA and the nautical tables used are shown after this text.

A capital O is the Swedish equivalent for East. A superscript t is equivalent to hours.

In **box 1**, $133^m 79^s$ is the sum of the minutes and seconds of the chronometer readings. As the hours are all the same there is no need to sum them. To find the mean value, divide the sum by the number of observations, in this case three. The navigator has started with $133^m/3$ which results in 44^m and 20^s. In order to be "compatible" with the sum of seconds, 79^s, those 20^s have been multiplied by 3 before summing, resulting in a sum of 139^s. This sum is now divided by 3, resulting in 46.3^s. The mean observation time thus becomes $9^h 44^m 46.3^s$, as shown on **line 2**.

A similar procedure is followed when meaning the altitudes. In **box 26**, 35°63.5′ is the sum of the three altitudes. The first step is to evaluate 35°/3 resulting in 11°40′. The excess 40′ is multiplied by 3 giving 120′, which is to be added to 63.5′. This addition was not finalized (and parts of it crossed out) because the navigator suddenly realized that 35°63.5′ is equal to 36°3.5′, which is easily divisible by 3, giving 12°1.2′. This value is copied to **box 28**.

The sextant used was probably a vernier model reading to 10″. The index correction seems to be 3′50″, noted as 3.8′ in **box 28** and **line 30**. Corrections for dip, refraction, parallax and semidiameter are combined and taken from a total correction table, **Table 19**, where a height of eye of 7 m is applied. This large height indicates that the vessel was in ballast. The table is entered with altitude 12° and hoe 7 m and gives the correction +6.9′. To care for the variable semidiameter during the year an additional correction of +0.2′ is given for November, giving a total of 7.1′. The true altitude for the time sight thus becomes 12°12.1′ which is used in the reduction **line 16**.

The chronometer time on **line 2** is corrected for an error of $2^m18.0^s$ slow. This error seems to be determined on 27 July at 0^h GMT. In **box 24** there is a calculation of number of days elapsed since that date: 5 whole days for July, 31 for August, 30 for September, 31 for October, and 20.4 days for November. With a rate of 0.2^s per day gaining, this gives an additional correction of -23.5^s, shown on **line 3**. This is indeed strange, as many opportunities for rating must have been at hand later. To rely on a close to four-month-old rating seems risky. But perhaps subsequent checks had shown that the rate was stable. Anyway, the resulting GMT for the time sight is $9^h46^m40.8^s$ as shown on **line 4**.

The almanac used onboard was presumably "The Nautical Almanac, Abridged for the Use of Seamen, for the Year 1937". This almanac gives, for every other hour of GMT, the quantity E and the declination for the Sun. E is the excess of the Greenwich hour angle of the sun over GMT. Thus, it includes the equation of time and the twelve hours difference between civil and astronomical time. From 1925 and onwards, GMT starts at midnight, while the hour angle is defined to start at apparent noon. The quantity R also shown in the almanac is the difference between Greenwich sidereal time and GMT. For readers accustomed to modern practise, in degrees: GHA Sun = 15·(E + GMT) and GHA Aries = 15·(R + GMT); if result >360°, subtract 360°.

The navigator has taken the 10^h values of E and declination, **lines 11 and 12**, without interpolation to the noted GMT. This results in a 0.1^s error in E and 0.1′ error in declination. As all calculations are performed to tenths of seconds of time and minutes of arc, this seems a little careless. The declination is converted to polar distance as shown on **line 13**, 109°52.3′. In order to find the log cosecant of that value, in a table that stops at 90°, the quantity 90°-|declination| is also calculated, **box 25**. This holds because csc(90°+x) = csc(90°-x).

Now all information necessary to reduce the time sight is available, except the latitude. The DR latitude could be used for this, but it is better to wait a few hours until the noon latitude is found, to get a determination nearer in time, thus reducing the error in the "run" between observations.

On **line 29** the measured noon altitude is shown. The same index correction is used and the total altitude correction is taken from **Table 19** as above, giving 7.7′+0.2′. The true altitude on **line 31** is converted to zenith distance on **line 32**. It is interesting to note that the altitude is labelled "S" and the zenith distance "N". I am not familiar with this labelling, but guess it was something taught at the navigation school. Obviously, the labelling is originated at the body. The declination (**line 33**) used is that for 12^h GMT, without any interpolation. Northerly zenith distance minus southerly declination gives the noon latitude, **line 34**.

In **box 10** there are two log readings shown, presumably 24.0 miles at the time of the a.m. sights and 33.2 miles at noon. However, a 10 miles distance on a course made good of N13°E true have been used in the calculations (this is verified by a note on the back side of the paper). Looking into the traverse table, **Table 3**, for course 13° and distance 10 miles give a difference of latitude of 9.7′ and a departure of 2.2′. These departure minutes are equal to nautical miles and noted on **line 27**.

At the time of the a.m. sight, the latitude was therefore 9.7′ south of the noon latitude. This is shown on **line 35**, with **line 36** giving the a.m. latitude. This value is copied to **line 15**.

Now all data for the time sight are given and the reduction is using the formula

$\sin^2(t/2)$ = csc(polar distance) · sec(latitude) · cos(halfsum) · sin(halfsum **-** altitude)

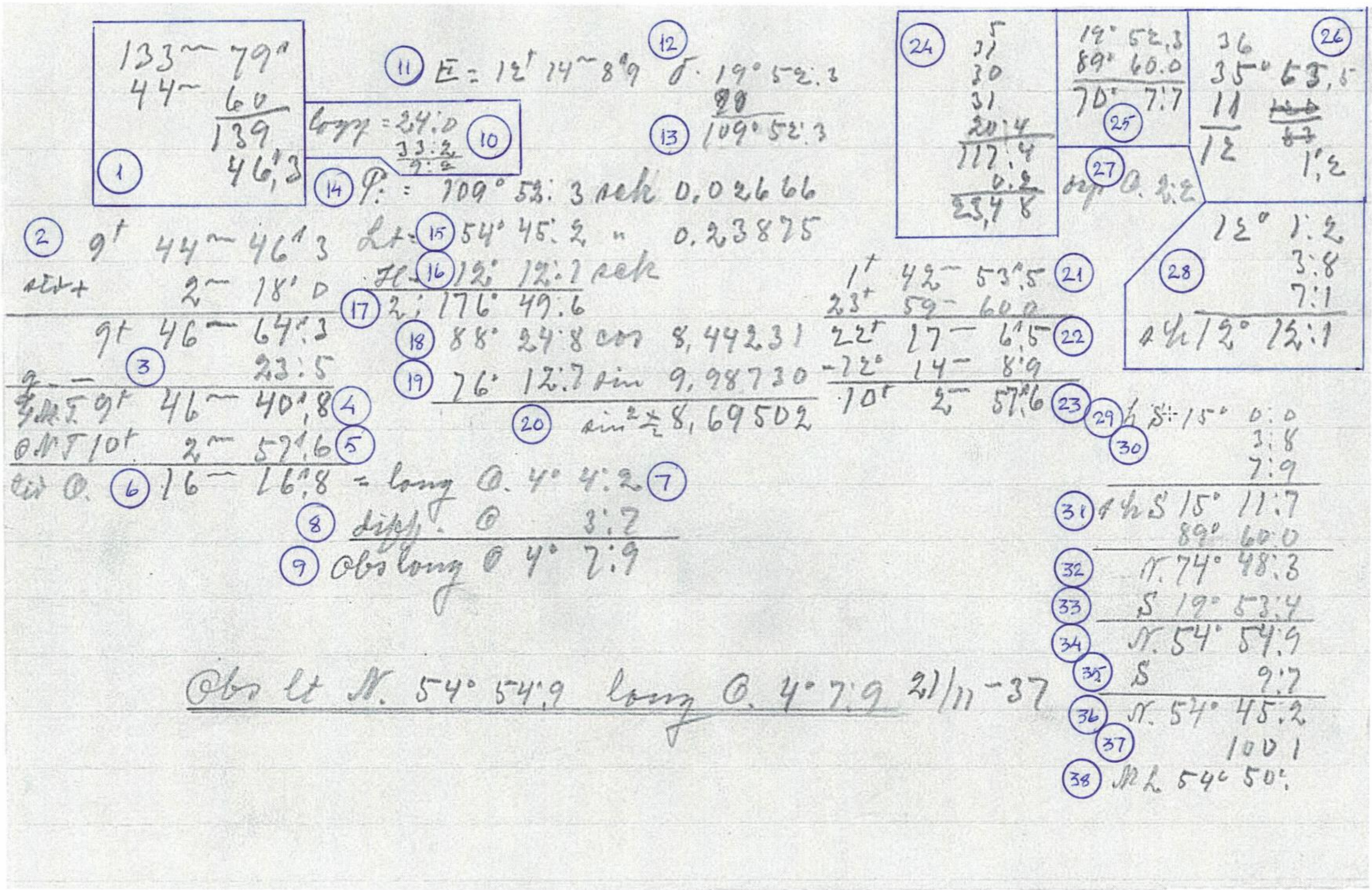
where *t* is the local hour angle, and halfsum = ½·(polar distance + latitude + altitude).

The formula is evaluated using logarithms as shown on **lines 14 to 20**. The label "sek" on **line 14** is a mistake, shall be "ksk" (csc), the log itself is however correct. The label "sek" on **line 16** should be moved one line up. The result on **line 20**, log $\sin^2(t/2)$ = 8.69502, is converted to hour angle by using **Table 49**, the navigator got the answer $1^h42^m53.5^s$ on **line 21**. (Strict interpolation actually gives $1^h42^m53.4^s$.) As the observation is made before noon, this value is subtracted from 24^h to give an hour angle of $22^h17^m6.5^s$ as shown on **line 22**. This hour angle is equal to local apparent time reckoned astronomically; by subtracting the quantity E the local mean time becomes $10^h2^m57.6^s$ as shown on **line 23**, which is copied to **line 5**. The difference between local mean time and GMT is longitude in time, reckoned eastwards from the Greenwich meridian, as shown on **line 6**. On **line 7** a conversion to arc is made. This conversion was probably done mentally, otherwise **Table 49** can be used for this as it shows time and arc side by side. The longitude on **line 7** is the longitude at the time of the a.m. observation. As mentioned above the departure between morning and noon sights were 2.2′. In order to convert this to difference in longitude we need to know the mean latitude of those sights. This is done by adding **line 34**, the noon latitude, and **line 36**, the a.m. latitude. The minutes are added and on **line 37** is the sum stated, 100[.]1′. Half of this gives the mean latitude 54°50′ on **line 38**. Utilizing **Table 4**, the departure value from **line 27** is converted to difference in longitude on **line 8**. The navigator got 3.7′, strict interpolation gives 3.8′. This difference is added to the a.m. longitude to give the noon longitude, **line 9**.

All logarithms are carefully interpolated (although it seems overkill to use tenths in seconds of time and minutes of arc, at least in the final position) and it looks like a ruler have been used to facilitate table reading and drawing straight lines at appropriate places.

--- I would like to express my thanks to Ed Popko for his encouragement and many good advices, also his superior help with image processing.

The barque Alastor in her early days



The day's work

130 **NOVEMBER, 1937** V

THE SUN

G.M.T.	Wednesd17 .7 *R*	Dec.¹	*E*	G.M.T.	Sunday 21 *R*	Dec.	*E*
h	h m s	° ′	h m s	h	h m s	° ′	h m s
00	03 42 31·9	S. 18 50·0	12 15 06·6	00	03 58 18·1	S. 19 46·7	12 14 15·1
02	03 42 51·6	18 51·2	12 15 05·6	02	03 58 37·8	19 47·8	12 14 13·9
04	03 43 11·3	18 52·5	12 15 04·7	04	03 58 57·5	19 48·9	12 14 12·6
06	03 43 31·0	18 53·7	12 15 03·7	06	03 59 17·2	19 50·1	12 14 11·4
08	03 43 50·7	18 54·9	12 15 02·8	08	03 59 37·0	19 51·2	12 14 10·2
10	03 44 10·4	18 56·2	12 15 01·8	10	03 59 56·7	19 52·3	12 14 08·9
12	03 44 30·1	18 57·4	12 15 00·9	12	04 00 16·4	19 53·4	12 14 07·7
14	03 44 49·9	18 58·6	12 14 59·9	14	04 00 36·1	19 54·5	12 14 06·4
16	03 45 09·6	18 59·8	12 14 58·9	16	04 00 55·8	19 55·6	12 14 05·2
18	03 45 29·3	19 01·1	12 14 57·9	18	04 01 15·6	19 56·7	12 14 03·9
20	03 45 49·0	19 02·3	12 14 57·0	20	04 01 35·3	19 57·8	12 14 02·6
22	03 46 08·7	19 03·5	12 14 56·0	22	04 01 55·0	19 58·9	12 14 01·4

The Nautical Almanac

T. 3.

Merkintätaulu asteiden mukaan. / Besticktabell efter grader.

13°.

a	b	c	a	b	c	a	b	c	a	b	c	a	b	c
1	1.0	0.2	**61**	59.4	13.7	**121**	117.9	27.2	**181**	176.4	40.7	**241**	234.8	54.2
2	1.9	0.4	**62**	60.4	13.9	**122**	118.9	27.4	**182**	177.3	40.9	**242**	235.8	54.4
3	2.9	0.7	**63**	61.4	14.2	**123**	119.8	27.7	**183**	178.3	41.2	**243**	236.8	54.7
4	3.9	0.9	**64**	62.4	14.4	**124**	120.8	27.9	**184**	179.3	41.4	**244**	237.7	54.9
5	4.9	1.1	**65**	63.3	14.6	**125**	121.8	28.1	**185**	180.3	41.6	**245**	238.7	55.1
6	5.8	1.3	**66**	64.3	14.8	**126**	122.8	28.3	**186**	181.2	41.8	**246**	239.7	55.3
7	6.8	1.6	**67**	65.3	15.1	**127**	123.7	28.6	**187**	182.2	42.1	**247**	240.7	55.6
8	7.8	1.8	**68**	66.3	15.3	**128**	124.7	28.8	**188**	183.2	42.3	**248**	241.6	55.8
9	8.8	2.0	**69**	67.2	15.5	**129**	125.7	29.0	**189**	184.2	42.5	**249**	242.6	56.0
10	9.7	2.2	**70**	68.2	15.7	**130**	126.7	29.2	**190**	185.1	42.7	**250**	243.6	56.2
11	10.7	2.5	**71**	69.2	16.0	**131**	127.6	29.5	**191**	186.1	43.0	**251**	244.6	56.5
12	11.7	2.7	**72**	70.2	16.2	**132**	128.6	29.7	**192**	187.1	43.2	**252**	245.5	56.7
13	12.7	2.9	**73**	71.1	16.4	**133**	129.6	29.9	**193**	188.1	43.4	**253**	246.5	56.9
14	13.6	3.1	**74**	72.1	16.6	**134**	130.6	30.1	**194**	189.0	43.6	**254**	247.5	57.1
15	14.6	3.4	**75**	73.1	16.9	**135**	131.5	30.4	**195**	190.0	43.9	**255**	248.5	57.4
16	15.6	3.6	**76**	74.1	17.1	**136**	132.5	30.6	**196**	191.0	44.1	**256**	249.4	57.6
17	16.6	3.8	**77**	75.0	17.3	**137**	133.5	30.8	**197**	192.0	44.3	**257**	250.4	57.8
18	17.5	4.0	**78**	76.0	17.5	**138**	134.5	31.0	**198**	192.9	44.5	**258**	251.4	58.0
19	18.5	4.3	**79**	77.0	17.8	**139**	135.4	31.3	**199**	193.9	44.8	**259**	252.4	58.3
20	19.5	4.5	**80**	77.9	18.0	**140**	136.4	31.5	**200**	194.9	45.0	**260**	253.3	58.5
21	20.5	4.7	**81**	78.9	18.2	**141**	137.4	31.7	**201**	195.8	45.2	**261**	254.3	58.7
22	21.4	4.9	**82**	79.9	18.4	**142**	138.4	31.9	**202**	196.8	45.4	**262**	255.3	58.9
23	22.4	5.2	**83**	80.9	18.7	**143**	139.3	32.2	**203**	197.8	45.7	**263**	256.3	59.2
24	23.4	5.4	**84**	81.8	18.9	**144**	140.3	32.4	**204**	198.8	45.9	**264**	257.2	59.4
25	24.4	5.6	**85**	82.8	19.1	**145**	141.3	32.6	**205**	199.7	46.1	**265**	258.2	59.6
26	25.3	5.8	**86**	83.8	19.3	**146**	142.3	32.8	**206**	200.7	46.3	**266**	259.2	59.8
27	26.3	6.1	**87**	84.8	19.6	**147**	143.2	33.1	**207**	201.7	46.6	**267**	260.2	60.1
28	27.3	6.3	**88**	85.7	19.8	**148**	144.2	33.3	**208**	202.7	46.8	**268**	261.1	60.3
29	28.3	6.5	**89**	86.7	20.0	**149**	145.2	33.5	**209**	203.6	47.0	**269**	262.1	60.5
30	29.2	6.7	**90**	87.7	20.2	**150**	146.2	33.7	**210**	204.6	47.2	**270**	263.1	60.7
31	30.2	7.0	**91**	88.7	20.5	**151**	147.1	34.0	**211**	205.6	47.5	**271**	264.1	61.0
32	31.2	7.2	**92**	89.6	20.7	**152**	148.1	34.2	**212**	206.6	47.7	**272**	265.0	61.2
33	32.2	7.4	**93**	90.6	20.9	**153**	149.1	34.4	**213**	207.5	47.9	**273**	266.0	61.4
34	33.1	7.6	**94**	91.6	21.1	**154**	150.1	34.6	**214**	208.5	48.1	**274**	267.0	61.6
35	34.1	7.9	**95**	92.6	21.4	**155**	151.0	34.9	**215**	209.5	48.4	**275**	268.0	61.9
36	35.1	8.1	**96**	93.5	21.6	**156**	152.0	35.1	**216**	210.5	48.6	**276**	268.9	62.1
37	36.1	8.3	**97**	94.5	21.8	**157**	153.0	35.3	**217**	211.4	48.8	**277**	269.9	62.3
38	37.0	8.5	**98**	95.5	22.0	**158**	154.0	35.5	**218**	212.4	49.0	**278**	270.9	62.5
39	38.0	8.8	**99**	96.5	22.3	**159**	154.9	35.8	**219**	213.4	49.3	**279**	271.8	62.8
40	39.0	9.0	**100**	97.4	22.5	**160**	155.9	36.0	**220**	214.4	49.5	**280**	272.8	63.0
41	39.9	9.2	**101**	98.4	22.7	**161**	156.9	36.2	**221**	215.3	49.7	**281**	273.8	63.2
42	40.9	9.4	**102**	99.4	22.9	**162**	157.8	36.4	**222**	216.3	49.9	**282**	274.8	63.4
43	41.9	9.7	**103**	100.4	23.2	**163**	158.8	36.7	**223**	217.3	50.2	**283**	275.7	63.7
44	42.9	9.9	**104**	101.3	23.4	**164**	159.8	36.9	**224**	218.3	50.4	**284**	276.7	63.9
45	43.8	10.1	**105**	102.3	23.6	**165**	160.8	37.1	**225**	219.2	50.6	**285**	277.7	64.1
46	44.8	10.3	**106**	103.3	23.8	**166**	161.7	37.3	**226**	220.2	50.8	**286**	278.7	64.3
47	45.8	10.6	**107**	104.3	24.1	**167**	162.7	37.6	**227**	221.2	51.1	**287**	279.6	64.6
48	46.8	10.8	**108**	105.2	24.3	**168**	163.7	37.8	**228**	222.2	51.3	**288**	280.6	64.8
49	47.7	11.0	**109**	106.2	24.5	**169**	164.7	38.0	**229**	223.1	51.5	**289**	281.6	65.0
50	48.7	11.2	**110**	107.2	24.7	**170**	165.6	38.2	**230**	224.1	51.7	**290**	282.6	65.2
51	49.7	11.5	**111**	108.2	25.0	**171**	166.6	38.5	**231**	225.1	52.0	**291**	283.5	65.5
52	50.7	11.7	**112**	109.1	25.2	**172**	167.6	38.7	**232**	226.1	52.2	**292**	284.5	65.7
53	51.6	11.9	**113**	110.1	25.4	**173**	168.6	38.9	**233**	227.0	52.4	**293**	285.5	65.9
54	52.6	12.1	**114**	111.1	25.6	**174**	169.5	39.1	**234**	228.0	52.6	**294**	286.5	66.1
55	53.6	12.4	**115**	112.1	25.9	**175**	170.5	39.4	**235**	229.0	52.9	**295**	287.4	66.4
56	54.6	12.6	**116**	113.0	26.1	**176**	171.5	39.6	**236**	230.0	53.1	**296**	288.4	66.6
57	55.5	12.8	**117**	114.0	26.3	**177**	172.5	39.8	**237**	230.9	53.3	**297**	289.4	66.8
58	56.5	13.0	**118**	115.0	26.5	**178**	173.4	40.0	**238**	231.9	53.5	**298**	290.4	67.0
59	57.5	13.3	**119**	116.0	26.8	**179**	174.4	40.3	**239**	232.9	53.8	**299**	291.3	67.3
60	58.5	13.5	**120**	116.9	27.0	**180**	175.4	40.5	**240**	233.8	54.0	**300**	292.3	67.5
a	c	b	a	c	b	a	c	b	a	c	b	a	c	b

77°.

Table 3 – traverse table

Departurin muuttaminen longitudin eroitukseksi.
Förvandling av departur till differens i longitud.

T. 4.

Keskulatit. Medellat.	100	200	300	1	2	3	4	5	6	7	8	9	Keskulatit. Medellat.
° ′	′	′	′	′	′	′	′	′	′	′	′	′	° ′
40 0	130.5	261.1	391.6	1.31	2.61	3.92	5.22	6.53	7.83	9.14	10.44	11.75	40 0
20	131.2	262.4	393.5	1.31	2.62	3.94	5.25	6.56	7.87	9.18	10.49	11.81	20
40	131.8	263.7	395.5	1.32	2.64	3.96	5.27	6.59	7.91	9.23	10.55	11.87	40
41 0	132.5	265.0	397.5	1.33	2.65	3.98	5.30	6.63	7.95	9.28	10.60	11.93	41 0
20	133.2	266.4	399.6	1.33	2.66	4.00	5.33	6.66	7.99	9.32	10.65	11.99	20
40	133.9	267.7	401.6	1.34	2.68	4.02	5.35	6.69	8.03	9.37	10.71	12.05	40
42 0	134.6	269.1	403.7	1.35	2.69	4.04	5.38	6.73	8.07	9.42	10.77	12.11	42 0
20	135.3	270.5	405.8	1.35	2.71	4.06	5.41	6.76	8.12	9.47	10.82	12.17	20
40	136.0	272.0	408.0	1.36	2.72	4.08	5.44	6.80	8.16	9.52	10.88	12.24	40
43 0	136.7	273.5	410.2	1.37	2.73	4.10	5.47	6.84	8.20	9.57	10.94	12.31	43 0
20	137.5	275.0	412.4	1.37	2.75	4.12	5.50	6.87	8.25	9.62	11.00	12.37	20
40	138.2	276.5	414.7	1.38	2.76	4.15	5.53	6.91	8.29	9.68	11.06	12.44	40
44 0	139.0	278.0	417.0	1.39	2.78	4.17	5.56	6.95	8.34	9.73	11.12	12.51	44 0
20	139.8	279.6	419.4	1.40	2.80	4.19	5.59	6.99	8.39	9.79	11.18	12.58	20
40	140.6	281.2	421.8	1.41	2.81	4.22	5.62	7.03	8.44	9.84	11.25	12.65	40
45 0	141.4	282.8	424.3	1.41	2.83	4.24	5.66	7.07	8.49	9.90	11.31	12.73	45 0
20	142.3	284.5	426.8	1.42	2.85	4.27	5.69	7.11	8.54	9.96	11.38	12.80	20
40	143.1	286.2	429.3	1.43	2.86	4.29	5.72	7.15	8.59	10.02	11.45	12.88	40
46 0	144.0	287.9	431.9	1.44	2.88	4.32	5.76	7.20	8.64	10.08	11.52	12.96	46 0
20	144.8	289.7	434.5	1.45	2.90	4.34	5.79	7.24	8.69	10.14	11.59	13.03	20
40	145.7	291.4	437.2	1.46	2.91	4.37	5.83	7.29	8.74	10.20	11.66	13.11	40
47 0	146.6	293.2	439.9	1.47	2.93	4.40	5.87	7.33	8.80	10.26	11.73	13.20	47 0
20	147.6	295.1	442.7	1.48	2.95	4.43	5.90	7.38	8.85	10.33	11.80	13.28	20
40	148.5	297.0	445.5	1.48	2.97	4.45	5.94	7.42	8.91	10.39	11.88	13.36	40
48 0	149.4	298.9	448.3	1.49	2.99	4.48	5.98	7.47	8.97	10.46	11.96	13.45	48 0
20	150.4	300.8	451.3	1.50	3.01	4.51	6.02	7.52	9.03	10.53	12.03	13.54	20
40	151.4	302.8	454.2	1.51	3.03	4.54	6.06	7.57	9.08	10.60	12.11	13.63	40
49 0	152.4	304.9	457.3	1.52	3.05	4.57	6.10	7.62	9.15	10.67	12.19	13.72	49 0
20	153.5	306.9	460.4	1.53	3.07	4.60	6.14	7.67	9.21	10.74	12.28	13.81	20
40	154.5	309.0	463.5	1.55	3.09	4.64	6.18	7.73	9.27	10.82	12.36	13.91	40
50 0	155.6	311.1	466.7	1.56	3.11	4.67	6.22	7.78	9.33	10.89	12.45	14.00	50 0
20	156.7	313.3	470.0	1.57	3.13	4.70	6.27	7.83	9.40	10.97	12.53	14.10	20
40	157.8	315.5	473.3	1.58	3.16	4.73	6.31	7.89	9.47	11.04	12.62	14.20	40
51 0	158.9	317.8	476.7	1.59	3.18	4.77	6.36	7.95	9.53	11.12	12.71	14.30	51 0
20	160.1	320.1	480.2	1.60	3.20	4.80	6.40	8.00	9.60	11.20	12.80	14.40	20
40	161.2	322.4	483.7	1.61	3.22	4.84	6.45	8.06	9.67	11.29	12.90	14.51	40
52 0	162.4	324.9	487.3	1.62	3.25	4.87	6.50	8.12	9.75	11.37	12.99	14.62	52 0
20	163.6	327.3	490.9	1.64	3.27	4.91	6.55	8.18	9.82	11.46	13.09	14.74	20
40	164.9	329.8	494.7	1.65	3.30	4.95	6.60	8.24	9.89	11.54	13.19	14.84	40
53 0	166.2	332.3	498.5	1.66	3.32	4.98	6.65	8.31	9.97	11.63	13.29	14.95	53 0
20	167.5	334.9	502.4	1.67	3.35	5.02	6.70	8.37	10.05	11.72	13.40	15.07	20
40	168.8	337.6	506.3	1.69	3.38	5.06	6.75	8.44	10.13	11.81	13.50	15.19	40
54 0	170.1	340.3	510.4	1.70	3.40	5.10	6.81	8.51	10.21	11.91	13.61	15.31	54 0
20	171.5	343.0	514.5	1.72	3.43	5.15	6.86	8.58	10.29	12.01	13.72	15.44	20
40	172.9	345.8	518.7	1.73	3.46	5.19	6.92	8.65	10.37	12.10	13.83	15.56	40
55 0	174.3	348.7	523.0	1.74	3.49	5.23	6.97	8.72	10.46	12.20	13.95	15.69	55 0
20	175.8	351.6	527.4	1.76	3.52	5.27	7.03	8.79	10.55	12.31	14.06	15.82	20
40	177.3	354.6	531.9	1.77	3.55	5.32	7.09	8.87	10.64	12.41	14.18	15.96	40
56 0	178.8	357.7	536.5	1.79	3.58	5.36	7.15	8.94	10.73	12.52	14.31	16.09	56 0
20	180.4	360.8	541.2	1.80	3.61	5.41	7.22	9.02	10.82	12.63	14.43	16.24	20
40	182.0	364.0	545.9	1.82	3.64	5.46	7.28	9.10	10.92	12.74	14.56	16.38	40
57 0	183.6	367.2	550.8	1.84	3.67	5.51	7.34	9.18	11.02	12.85	14.69	16.52	57 0
20	185.3	370.5	555.8	1.85	3.71	5.56	7.41	9.26	11.12	12.97	14.82	16.67	20
40	187.0	373.9	560.9	1.87	3.74	5.61	7.48	9.35	11.22	13.09	14.96	16.83	40
58 0	188.7	377.4	566.1	1.89	3.77	5.66	7.55	9.44	11.32	13.21	15.10	16.98	58 0
20	190.5	381.0	571.5	1.90	3.81	5.71	7.62	9.52	11.43	13.33	15.24	17.14	20
40	192.3	384.6	576.9	1.92	3.85	5.77	7.69	9.62	11.54	13.46	15.38	17.31	40
59 0	194.2	388.3	582.5	1.94	3.88	5.82	7.77	9.71	11.65	13.59	15.53	17.47	59 0
20	196.1	392.1	588.2	1.96	3.92	5.88	7.84	9.80	11.76	13.72	15.68	17.65	20
40	198.0	396.0	594.0	1.98	3.96	5.94	7.92	9.90	11.88	13.86	15.84	17.82	40
Keskulatit. Medellat.	100	200	300	1	2	3	4	5	6	7	8	9	Keskulatit. Medellat.

Departurin minuutit. Minuter av departur.

Table 4 – departure to diff long

⊙ **Auringon alasyrjän tarkastetun korkeuden täysioikaisu.**
Totalrättelse till observerad höjd av solens underrand.

T. 19.

Tarkastettu korkeus Obs. höjd		Silmäin korkeus metreissä — Ögats höjd i meter: 1	2	3	4	4.5	5	5.5	6	7	8	9	10	11	12	13	14	15	16
° ′		′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′	′
7 0	+	6.9	6.1	5.6	5.1	4.8	4.6	4.4	4.2	3.9	3.5	3.2	2.9	2.6	2.4	2.1	1.8	1.6	1.4
10	+	7.1	6.3	5.7	5.2	5.0	4.8	4.6	4.4	4.0	3.7	3.4	3.1	2.8	2.5	2.3	2.0	1.8	1.5
20	+	7.2	6.5	5.9	5.4	5.1	4.9	4.7	4.5	4.2	3.8	3.5	3.2	2.9	2.7	2.4	2.1	1.9	1.7
30	+	7.4	6.6	6.0	5.5	5.3	5.1	4.9	4.7	4.3	4.0	3.7	3.4	3.1	2.8	2.6	2.3	2.0	1.8
40	+	7.5	6.7	6.2	5.7	5.4	5.2	5.0	4.8	4.5	4.1	3.8	3.5	3.2	3.0	2.7	2.4	2.2	2.0
50	+	7.6	6.9	6.3	5.8	5.5	5.3	5.1	4.9	4.6	4.2	3.9	3.6	3.4	3.1	2.8	2.6	2.3	2.1
8 0	+	7.8	7.0	6.4	5.9	5.7	5.5	5.3	5.1	4.8	4.4	4.1	3.8	3.5	3.3	3.0	2.7	2.5	2.2
20	+	8.0	7.2	6.6	6.2	5.9	5.7	5.5	5.3	5.0	4.6	4.3	4.0	3.7	3.5	3.2	2.9	2.7	2.5
40	+	8.2	7.5	6.9	6.4	6.2	5.9	5.8	5.6	5.2	4.9	4.6	4.2	4.0	3.7	3.4	3.2	2.9	2.7
9 0	+	8.4	7.7	7.1	6.6	6.4	6.2	6.0	5.8	5.4	5.1	4.8	4.5	4.2	3.9	3.6	3.4	3.2	2.9
20	+	8.6	7.9	7.3	6.8	6.6	6.4	6.2	6.0	5.6	5.3	5.0	4.7	4.4	4.1	3.8	3.6	3.4	3.1
40	+	8.8	8.1	7.5	7.0	6.8	6.6	6.4	6.2	5.8	5.5	5.1	4.9	4.6	4.3	4.0	3.8	3.6	3.3
10 0	+	9.0	8.2	7.7	7.2	6.9	6.7	6.5	6.3	6.0	5.6	5.3	5.0	4.8	4.5	4.2	4.0	3.7	3.5
20	+	9.2	8.4	7.8	7.3	7.1	6.9	6.7	6.5	6.1	5.8	5.5	5.2	4.9	4.6	4.4	4.1	3.9	3.7
40	+	9.3	8.6	8.0	7.5	7.3	7.1	6.9	6.6	6.3	6.0	5.6	5.4	5.1	4.8	4.5	4.3	4.0	3.8
11 0	+	9.5	8.7	8.1	7.6	7.4	7.2	7.0	6.8	6.5	6.1	5.8	5.5	5.2	5.0	4.7	4.4	4.2	4.0
20	+	9.6	8.9	8.3	7.8	7.5	7.3	7.1	6.9	6.6	6.2	5.9	5.6	5.4	5.1	4.8	4.6	4.3	4.1
40	+	9.7	9.0	8.4	7.9	7.7	7.5	7.3	7.1	6.7	6.4	6.1	5.8	5.5	5.2	5.0	4.7	4.5	4.2
12 0	+	9.9	9.1	8.5	8.0	7.8	7.6	7.4	7.2	6.9	6.5	6.2	5.9	5.6	5.4	5.1	4.8	4.6	4.4
20	+	10.0	9.2	8.6	8.2	7.9	7.7	7.5	7.3	7.0	6.6	6.3	6.0	5.7	5.5	5.2	5.0	4.7	4.5
40	+	10.1	9.4	8.8	8.3	8.0	7.8	7.6	7.4	7.1	6.7	6.4	6.1	5.8	5.6	5.3	5.1	4.8	4.6
13 0	+	10.2	9.5	8.9	8.4	8.1	7.9	7.7	7.5	7.2	6.9	6.5	6.3	6.0	5.7	5.4	5.2	5.0	4.7
30	+	10.4	9.6	9.0	8.5	8.3	8.1	7.9	7.7	7.3	7.0	6.7	6.4	6.1	5.9	5.6	5.3	5.1	4.9
14 0	+	10.5	9.7	9.2	8.7	8.4	8.2	8.0	7.8	7.5	7.2	6.8	6.6	6.3	6.0	5.7	5.5	5.3	5.0
30	+	10.7	9.9	9.3	8.8	8.6	8.4	8.2	8.0	7.6	7.3	7.0	6.7	6.4	6.1	5.9	5.6	5.4	5.1
15 0	+	10.8	10.0	9.4	8.9	8.7	8.5	8.3	8.1	7.7	7.4	7.1	6.8	6.5	6.3	6.0	5.8	5.5	5.3
30	+	10.9	10.1	9.5	9.0	8.8	8.6	8.4	8.2	7.9	7.5	7.2	6.9	6.6	6.4	6.1	5.9	5.6	5.4
16	+	11.0	10.2	9.6	9.2	8.9	8.7	8.5	8.3	8.0	7.6	7.3	7.0	6.8	6.5	6.2	6.0	5.7	5.5
17	+	11.2	10.4	9.8	9.4	9.1	8.9	8.7	8.5	8.2	7.8	7.5	7.2	7.0	6.7	6.4	6.2	5.9	5.7
18	+	11.4	10.6	10.0	9.5	9.3	9.1	8.9	8.7	8.4	8.0	7.7	7.4	7.1	6.9	6.6	6.4	6.1	5.9
19	+	11.5	10.8	10.2	9.7	9.5	9.3	9.1	8.9	8.5	8.2	7.9	7.6	7.3	7.0	6.8	6.5	6.3	6.0
20	+	11.7	10.9	10.3	9.8	9.6	9.4	9.2	9.0	8.7	8.3	8.0	7.7	7.4	7.2	6.9	6.7	6.4	6.2
21	+	11.8	11.0	10.5	10.0	9.7	9.5	9.3	9.1	8.8	8.5	8.1	7.9	7.6	7.3	7.0	6.8	6.6	6.3
22	+	11.9	11.2	10.6	10.1	9.9	9.7	9.5	9.3	8.9	8.6	8.3	8.0	7.7	7.4	7.2	6.9	6.7	6.5
24	+	12.2	11.4	10.8	10.3	10.1	9.9	9.7	9.5	9.1	8.8	8.5	8.2	7.9	7.7	7.4	7.1	6.9	6.7
26	+	12.3	11.6	11.0	10.5	10.3	10.1	9.9	9.7	9.3	9.0	8.7	8.4	8.1	7.8	7.5	7.3	7.1	6.9
28	+	12.5	11.8	11.2	10.7	10.5	10.2	10.0	9.8	9.5	9.2	8.8	8.6	8.3	8.0	7.7	7.5	7.2	7.0
30	+	12.6	11.9	11.3	10.8	10.6	10.4	10.2	10.0	9.6	9.3	9.0	8.7	8.4	8.1	7.8	7.6	7.4	7.2
32	+	12.8	12.0	11.4	10.9	10.7	10.5	10.3	10.1	9.8	9.4	9.1	8.8	8.5	8.3	8.0	7.8	7.5	7.3
34	+	12.9	12.1	11.5	11.1	10.8	10.6	10.4	10.2	9.9	9.5	9.2	8.9	8.6	8.4	8.1	7.9	7.6	7.4
36	+	13.0	12.2	11.6	11.2	10.9	10.7	10.5	10.3	10.0	9.6	9.3	9.0	8.7	8.5	8.2	8.0	7.7	7.5
38	+	13.1	12.3	11.7	11.3	11.0	10.8	10.6	10.4	10.1	9.7	9.4	9.1	8.8	8.6	8.3	8.1	7.8	7.6
40	+	13.2	12.4	11.8	11.3	11.1	10.9	10.7	10.5	10.2	9.8	9.5	9.2	8.9	8.7	8.4	8.1	7.9	7.7
45	+	13 3	12.6	12.0	11.5	11.3	11.1	10.9	10.7	10.3	10.0	9.6	9.4	9.1	8.8	8.6	8.3	8.1	7.9
50	+	13.5	12.7	12.2	11.7	11.4	11.2	11.0	10.8	10.5	10.1	9.8	9.5	9.3	9.0	8.7	8.5	8.2	8.0
55	+	13.6	12.8	12.3	11.8	11.5	11.3	11.1	10.9	10.6	10.2	9.9	9.6	9.4	9.1	8.8	8.6	8.4	8.1
60	+	13.7	12.9	12.4	11.9	11.6	11.4	11.2	11.0	10.7	10.4	10.0	9.7	9.5	9.2	8.9	8.7	8.5	8.2
65	+	13.8	13.1	12.5	12.0	11.8	11.6	11.3	11.1	10.8	10.5	10.2	9.9	9.6	9.3	9.0	8.8	8.6	8.3
70	+	13.9	13.1	12.6	12.1	11.8	11.6	11.4	11.2	10.9	10.5	10.3	10.0	9.7	9.4	9.1	8.9	8.7	8.4
80	+	14.1	13.3	12.7	12.2	12.0	11.8	11.6	11.4	11.1	10.7	10.4	10.1	9.8	9.6	9.3	9.1	8.8	8.6
90	+	14.2	13.4	12.8	12.4	12.1	11.9	11.7	11.5	11.2	10.8	10.5	10.3	10.0	9.7	9.4	9.2	9.0	8.7

Auringon alasyrjän lisäoikaisu, johtuen puolikeskistäjän muuttumisesta.
Tilläggskorrektion för solens underrands höjd, på grund av halvdiam. förändring.

Tammik. Jan.	Helmik. Febr.	Maaliskuu Mars	Huhtik. April 1—15	Huhtik. April 16—30	Toukok. Maj 1—15	Toukok. Maj 16—31	Kesäk. Juni	Heinäk. Juli	Elok. Aug.	Syysk. Sept. 1—15	Syysk. Sept. 16—30	Lokak. Okt.	Marr.k. Nov.	Jouluk. Dec.
+0.3′	+0.2′	+0.1′	0′	—0.1′	—0.1′	—0.2′	—0.2′	—0.2′	—0.2′	—0.1′	0′	+0.1′	+0.2′	+0.3′

⊙ Auringon yläsyrjän lisäoikaisu — Tilläggskorrektion för solens överrands höjd.

Tammik. Jan.	Helmik. Febr.	Maalis Mars	Huhtik. April 1—15	Huhtik. April 16—30	Toukok. Maj 1—15	Toukok. Maj 16—31	Kesäk. Juni	Heinäk. Juli	Elok. Aug.	Syysk. Sept 1—15	Syysk. Sept 16—30	Lokak. Okt	Marr.k. Nov.	Jouluk Dec.
—32.3′	—32.2′	—32.1′	—32′	—31.9′	—31.9′	—31.8′	—31.8′	—31.8′	—31.8′	—31.9′	—32′	—32.1′	—32.2′	—32.3′

Table 19 – total correction Sun

Kolmiomitannollisten suureiden logaritmit.

Logaritmer för de trigonometriska funktionerna.

T. 49.

25°	1t	$\sin^2\frac{x}{2}$	Sinus	Suhde-os. Pr. p.	Kose-kant	Tangent	Suhde-os. Pr. p.	Kotan-gent	Sekant	Suhde-os. Pr. p.	Kosinus	1s—5 2—10 3—15		
′	m s												m s	′
0	40 0	8.67067	9.62595	′	0.37405	9.66867	′	0.33133	0.04272	′	9.95728	9.46043	20 0	60
1	4	8.67124	9.62622	.01 3	0.37378	9.66900	0.1 3	0.33100	0.04278	0.1 1	9.95722	9.46023	56	59
2	8	8.67181	9.62649	2 5	0.37351	9.66933	2 7	0.33067	0.04284	2 1	9.95716	9.46004	52	58
3	12	8.67238	9.62676	3 8	0.37324	9.66966	3 10	0.33034	0.04290	3 2	9.95710	9.45984	48	57
4	16	8.67295	9.62703	4 11 5 14	0.37297	9.66999	4 13 5 16	0.33001	0.04296	4 2 5 3	9.95704	9.45964	44	56
5	20	8.67352	9.62730	6 16	0.37270	9.67032	6 20	0.32968	0.04302	6 4	9.95698	9.45944	40	55
6	24	8.67409	9.62757	7 19	0.37243	9.67065	7 23	0.32935	0.04308	7 4	9.95692	9.45924	36	54
7	28	8.67465	9.62784	8 22	0.37216	9.67098	8 26	0.32902	0.04314	8 5	9.95686	9.45904	32	53
8	32	8.67522	9.62811	9 24	0.37189	9.67131	9 30	0.32869	0.04320	9 5	9.95680	9.45884	28	52
9	36	8.67579	9.62838		0.37162	9.67163		0.32837	0.04326		9.95674	9.45865	24	51
10	40	8.67635	9.62865	′	0.37135	9.67196	′	0.32804	0.04332	′	9.95668	9.45845	20	50
11	44	8.67692	9.62892	0.1 3	0.37108	9.67229	0.1 3	0.32771	0.04337	0.1 1	9.95663	9.45825	16	49
12	48	8.67748	9.62918	2 5	0.37082	9.67262	2 7	0.32738	0.04343	2 1	9.95657	9.45805	12	48
13	52	8.67805	9.62945	3 8	0.37055	9.67295	3 10	0.32705	0.04349	3 2	9.95651	9.45785	8	47
14	56	8.67861	9.62972	4 11 5 13	0.37028	9.67327	4 13 5 16	0.32673	0.04355	4 2 5 3	9.95645	9.45765	4	46
15	41 0	8.67918	9.62999	6 16	0.37001	9.67360	6 20	0.32640	0.04361	6 4	9.95639	9.45745	19 0	45
16	4	8.67974	9.63026	7 19	0.36974	9.67393	7 23	0.32607	0.04367	7 4	9.95633	9.45725	56	44
17	8	8.68030	9.63052	8 21	0.36948	9.67426	8 26	0.32574	0.04373	8 5	9.95627	9.45705	52	43
18	12	8.68087	9.63079	9 24	0.36921	9.67458	9 30	0.32542	0.04379	9 5	9.95621	9.45685	48	42
19	16	8.68143	9.63106		0.36894	9.67491		0.32509	0.04385		9.95615	9.45665	44	41
20	20	8.68199	9.63133	′	0.36867	9.67524	′	0.32476	0.04391	′	9.95609	9.45645	40	40
21	24	8.68255	9.63159	0.1 3	0.36841	9.67556	0.1 3	0.32444	0.04397	0.1 1	9.95603	9.45625	36	39
22	28	8.68312	9.63186	2 5	0.36814	9.67589	2 7	0.32411	0.04403	2 1	9.95597	9.45605	32	38
23	32	8.68368	9.63213	3 8	0.36787	9.67622	3 10	0.32378	0.04409	3 2	9.95591	9.45586	28	37
24	36	8.68424	9.63239	4 11 5 13	0.36761	9.67654	4 13 5 16	0.32346	0.04415	4 2 5 3	9.95585	9.45566	24	36
25	40	8.68480	9.63266	6 16	0.36734	9.67687	6 20	0.32313	0.04421	6 4	9.95579	9.45546	20	35
26	44	8.68536	9.63292	7 19	0.36708	9.67719	7 23	0.32281	0.04427	7 4	9.95573	9.45526	16	34
27	48	8.68592	9.63319	8 21	0.36681	9.67752	8 26	0.32248	0.04433	8 5	9.95567	9.45506	12	33
28	52	8.68648	9.63345	9 24	0.36655	9.67785	9 29	0.32215	0.04439	9 5	9.95561	9.45486	8	32
29	56	8.68704	9.63372		0.36628	9.67817		0.32183	0.04445		9.95555	9.45466	4	31
30	42 0	8.68759	9.63398	′	0.36602	9.67850	′	0.32150	0.04451	′	9.95549	9.45446	18 0	30
31	4	8.68815	9.63425	0.1 3	0.36575	9.67882	0.1 3	0.32118	0.04457	0.1 1	9.95543	9.45426	56	29
32	8	8.68871	9.63451	2 5	0.36549	9.67915	2 6	0.32085	0.04463	2 1	9.95537	9.45405	52	28
33	12	8.68927	9.63478	3 8	0.36522	9.67947	3 10	0.32053	0.04469	3 2	9.95531	9.45385	48	27
34	16	8.68982	9.63504	4 11 5 13	0.36496	9.67980	4 13 5 16	0.32020	0.04475	4 2 5 3	9.95525	9.45365	44	26
35	20	8.69038	9.63531	6 16	0.36469	9.68012	6 19	0.31988	0.04481	6 4	9.95519	9.45345	40	25
36	24	8.69094	9.63557	7 19	0.36443	9.68044	7 23	0.31956	0.04487	7 4	9.95513	9.45325	36	24
37	28	8.69149	9.63583	8 21	0.36417	9.68077	8 26	0.31923	0.04493	8 5	9.95507	9.45305	32	23
38	32	8.69205	9.63610	9 24	0.36390	9.68109	9 29	0.31891	0.04500	9 5	9.95500	9.45285	28	22
39	36	8.69260	9.63636		0.36364	9.68142		0.31858	0.04506		9.95494	9.45265	24	21
40	40	8.69316	9.63662	′	0.36338	9.68174	′	0.31826	0.04512	′	9.95488	9.45245	20	20
41	44	8.69371	9.63689	0.1 3	0.36311	9.68206	0.1 3	0.31794	0.04518	0.1 1	9.95482	9.45225	16	19
42	48	8.69427	9.63715	2 5	0.36285	9.68239	2 6	0.31761	0.04524	2 1	9.95476	9.45205	12	18
43	52	8.69482	9.63741	3 8	0.36259	9.68271	3 10	0.31729	0.04530	3 2	9.95470	9.45185	8	17
44	56	8.69537	9.63767	4 10 5 13	0.36233	9.68303	4 13 5 16	0.31697	0.04536	4 2 5 3	9.95464	9.45165	4	16
45	43 0	8.69593	9.63794	6 16	0.36206	9.68336	6 19	0.31664	0.04542	6 4	9.95458	9.45144	17 0	15
46	4	8.69648	9.63820	7 18	0.36180	9.68368	7 23	0.31632	0.04548	7 4	9.95452	9.45124	56	14
47	8	8.69703	9.63846	8 21	0.36154	9.68400	8 26	0.31600	0.04554	8 5	9.95446	9.45104	52	13
48	12	8.69758	9.63872	9 24	0.36128	9.68432	9 29	0.31568	0.04560	9 5	9.95440	9.45084	48	12
49	16	8.69813	9.63898		0.36102	9.68465		0.31535	0.04566		9.95434	9.45064	44	11
50	20	8.69869	9.63924	′	0.36076	9.68497	′	0.31503	0.04573	′	9.95427	9.45044	40	10
51	24	8.69924	9.63950	0.1 3	0.36050	9.68529	0.1 3	0.31471	0.04579	0.1 1	9.95421	9.45024	36	9
52	28	8.69979	9.63976	2 5	0.36024	9.68561	2 6	0.31439	0.04585	2 1	9.95415	9.45003	32	8
53	32	8.70034	9.64002	3 8	0.35998	9.68593	3 10	0.31407	0.04591	3 2	9.95409	9.44983	28	7
54	36	8.70089	9.64028	4 10 5 13	0.35972	9.68626	4 13 5 16	0.31374	0.04597	4 2 5 3	9.95403	9.44963	24	6
55	40	8.70144	9.64054	6 16	0.35946	9.68658	6 19	0.31342	0.04603	6 4	9.95397	9.44943	20	5
56	44	8.70198	9.64080	7 18	0.35920	9.68690	7 22	0.31310	0.04609	7 4	9.95391	9.44923	16	4
57	48	8.70253	9.64106	8 21	0.35894	9.68722	8 26	0.31278	0.04616	8 5	9.95384	9.44903	12	3
58	52	8.70308	9.64132	9 23	0.35868	9.68754	9 29	0.31246	0.04622	9 5	9.95378	9.44882	8	2
59	56	8.70363	9.64158		0.35842	9.68786		0.31214	0.04628		9.95372	9.44862	4	1
60	44 0	8.70418	9.64184		0.35816	9.68818		0.31182	0.04634		9.95366	9.44842	16 0	0
		1s—14 2—28 3—42	Kosinus	Suhde-os. Pr. p.	Sekant	Kotan-gent	Suhde-os. Pr. p.	Tangent	Kose-kant	Suhde-os. Pr. p.	Sinus	$\sin^2\frac{x}{2}$	4t	64°

Table 49 – log trig table