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A FORTRAN PROGRAM FOR THE CALCULATION OF HOURLY VALUES
OF ASTRONOMICAL TIDE
AND TIME AND HEIGHT OF HIGH AND LOW WATER

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ABSTRACT

A listing of the FORTRAN statements for a program for computing hourly values and times and heights of high and low astronomical tide is presented. Also shown are a flow chart of the logic of the program, descriptions and samples of the program control cards and data cards, and a sample of each type of output.

1. INTRODUCTION

The change from analog to digital computation of tides began in 1956 when the first program for the prediction of hourly tide heights by the harmonic method was prepared for the IBM 701 in machine language. This method was subsequently programmed in machine language for the IBM 704 and the IBM 7094. The 7094 program had a subroutine which computed the times and heights of high and low water. This method was described by Harris, Pore, and Cummings [1]. The most recent version of this program is written in FORTRAN IV for the IBM 7094 and consequently is easily adapted to any computer with adequate memory using the FORTRAN system. It requires 1.7 minutes on the IBM 7094 to compute one year of hourly heights and times and heights of high and low water.

The purpose of this report is to document the actual FORTRAN program for prospective users. Full details of the FORTRAN program are presented along with instructions for the preparation of the program control cards. Little description of the actual harmonic tide prediction method is presented because this is available elsewhere [1, 2].

2. MATHEMATICAL PROCEDURE

The height of the tide at any time, as given by Schureman [2], may be written:

$$h = H_0 + \sum_{n=1}^N f_n H_n \cos [a_n t + (V_0 + u)_n - K'_n], \quad (1)$$

where

h	= height of tide at any time t .
H_o	= mean height of water level above datum used for prediction.
H_n	= mean amplitude of any constituent A_n .
f_n	= factor for reducing mean amplitude to year of prediction.
a_n	= hourly speed of constituent A_n .
t	= time, in hours, reckoned from beginning of year of prediction.
$(V_o + u)_n$	= Greenwich equilibrium argument of constituent A_n when $t=0$.
K'_n	= modified epoch of constituent A_n .
N	= number of constituents used for the particular station.

The cosines of the argument $[a_n t + (V_o + u)_n - K'_n]$ are supplied for the calculation by a relatively efficient "table look-up" procedure.

The logic of the procedure is shown in the flow chart of figure 1.

3. PROGRAM DESCRIPTION

The program is written in FORTRAN IV language and has been compiled and tested on the IBM 7094. It should be adaptable to any computer with adequate memory which utilizes the FORTRAN system.

A listing of the FORTRAN source statements is presented in Appendix A. The steps in the program described below are keyed to the source statements by the numbers and scale added to the right edge of the listing in Appendix A.

1. Initialize MS, MY, and MD, the control words which determine if more than one problem is to be done. Specify that constants for the station, year, and date will be read in. After the first set of calculations these variables may be set to zero if station, year, or date are not being changed.

2. Read-in the table of constituent speeds $A(J)$. The program is compiled to accept 37 constituents. This number can be increased by a change of the DIMENSION statement and a change of the indexing of the appropriate statements.

3. Convert the constituent speeds to units such that 1024 units are equal to $\pi/2$.

4. Read station name from punched card (72H). The amplitude of each constituent (AMP(J)), and the modified epoch of each constituent (EPOCH(J)) are read in for the station. These require 6 punched cards. The first word on each card is the assigned station number. The second word is the card number, 1 through 6. These station cards must be in correct numerical order

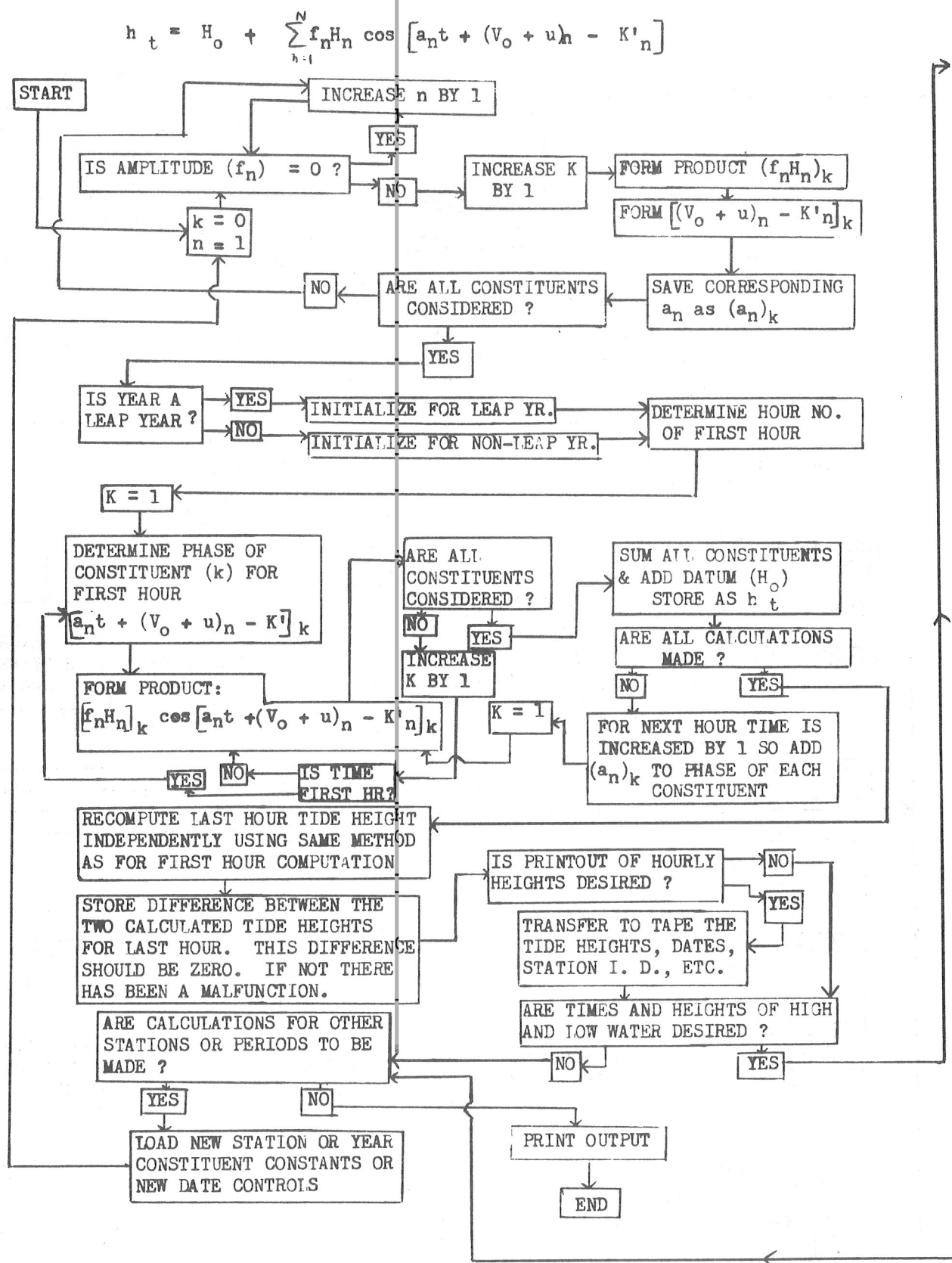
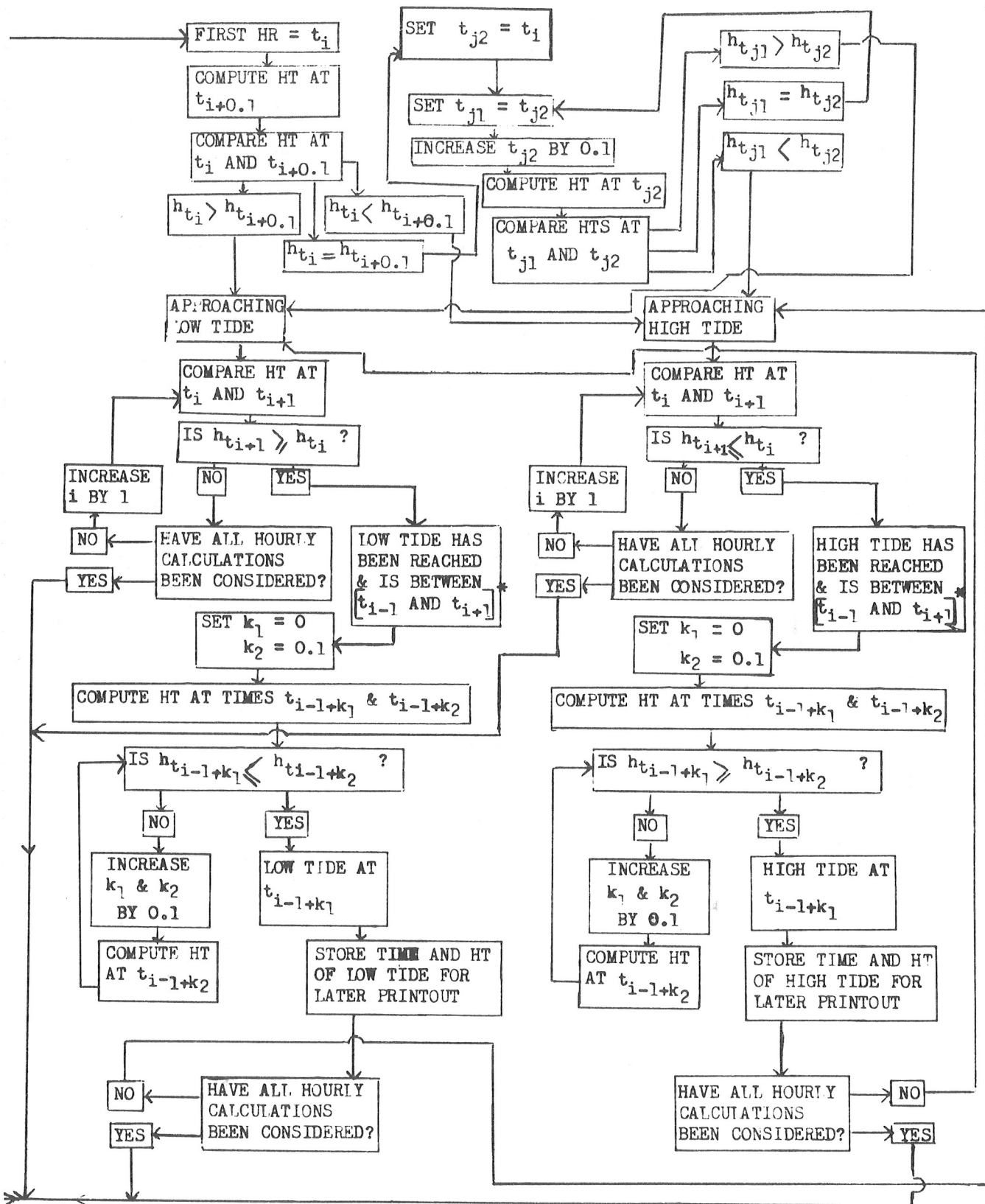


Figure 1. - Flow chart showing the logic of the procedure for the astronomical tide prediction program.



* If t_1 is first hour, extreme tide is between t_i and t_{i+1} rather than between t_{i-1} and t_{i+1} . The search for high or low tide is made between these two hours.

so that the amplitudes and epochs are read in for the appropriate constituents. The station numbers are compared for consistency and the order of the six cards is checked.

5. Read-in the datum plane (DATUM) and control word (IND). The tide heights are calculated with reference to mean sea level datum plane. The amount in feet specified by DATUM is added to the calculations before they are printed. The control word IND determines if hourly calculations, high and low water calculations, or both are to be printed. IND is set to 1 for highs and lows only, 2 for both hourly values and highs and lows, and 3 for hourly values only.

6. Determine if year constants are to be read in.

7. Read-in the node factor (XODE (J)) and the equilibrium argument (VPU(J)) for each constituent for the particular year. This requires 5 cards. The first word is the year, the second specifies whether the year of calculation is a leap year or a non-leap year (1 for leap year and 0 for non-leap year). The third word is the card number, 1 through 5. The cards are checked for year consistency and for card order.

8. Determine if a date card is to be read in.

9. Read-in date control card consisting of 12 time periods. MO(J) is month, NBDAY(J) is the beginning day, and NEDAY(J) is the ending day. If calculations are for less than 12 time periods, the unused portion of the card is left blank. The unused words MO(J), NBDAY(J), NEDAY(J) are therefore read in as zero.

10. Examine amplitudes of the constituents (AMP(J)) for zero and form a set of tables consisting of AMPA(K) which is $f_n H_n$ in equation 1, EPOCH(K) which is $(V_n + u_n) - K'_n$ in equation 1, and SPD(K) which is a_n in equation 1. The resulting set of constants is for the constituents of non-zero amplitude. Also constituent speeds in tenths of hours are computed and stored as SP(K).

11. Compute NOCON, the number of non-zero constituents, which is the number of constituents to be used in the calculations.

12. Put the month, beginning, and ending dates in MO(13), NB(13), and NEDAY(13).

13. Check for blank (zero) month number which indicates calculations for the last time period have been completed.

14. Determine number of days (NODAYS) and number of hours (NOHRS) for which calculations are to be made.

15. Check whether year is leap year or non-leap year.

16. Determine the first hour number of the year for which calculations are to be made (FIRST). The first hour number of each month is stored in table TABHR(K). There are 12 values for non-leap years and 12 for leap years. First is saved as NFIRST.

17. Determine phase angle of each constituent for the first hour of calculation. These arguments are then reduced to values of less than 2π .
18. Determine for all hours after the first the phases of the constituents by adding the speed of each constituent SPD(J) to the previous phase (ARG(J)). These also are reduced to less than 2π .
19. Determine the quadrant of the phase of the constituent. This is necessary as program utilizes a cosine table of 1025 values, from 0 to $\pi/2$.
20. From NP determine which value of the cosine table to use for the particular constituent; NP is determined by rounding.
21. Accumulate the value of the tide for a particular hour STORX(K) for those constituents which are in an increasing phase.
22. Same as 20.
23. Same as 21 except for constituents which are in a decreasing phase.
24. Find time of last hour for which calculations are made. This is used for calculating the tide height for the last hour the second time by the method used in the first hour in step 17. This independent calculation of the last hour is compared to the value for the last hour obtained by the short cut method of step 18.
25. Transfer for calculation of the last hour tide height.
26. Find CKSUM, the difference between the two calculations of the last hour tide. Should be very near zero.
27. Add datum plane to the tide calculations.
28. Write a heading line consisting of year, month, datum, number of constituents, and CKSUM.
29. Write out the hourly calculations of tide.
30. Check to determine if hourly values only are desired.
31. Check constituent constants cards for errors. (Format of error messages is shown in listing in Appendix.)
32. Initialize ITEMS to zero. ITEMS builds up to twice the number of extreme tides.
33. Set number of one-hour time intervals.
34. Begin search for tide extremes.
35. Test to determine if first hour is being considered.
36. Initialize for first hour.

37. States that an extreme tide will occur between TIME - 1 and TIME + 1 hours.

38. Compute tide heights at tenth of hour intervals. Similar to computation of hourly tide heights.

39. Transfer. (Depends on whether the program is searching for a high tide or a low tide.)

40. Initialize for low tide search.

41. Search for low tide.

42. Check to determine if low tide has been found.

43. Initialize for search of high tide.

44. Search for high tide.

45. Check to determine if high tide has been found.

46. Determine if first tide extreme is a high or low tide.

47. Store time and height of extreme tide.

48. Transfer appropriately to search for high or low tide.

49. Change hours and tenths of hours to hours and minutes.

50. Set sign of all zero heights to plus.

51. Set initial day number.

52. Write four heading lines.

53. Write times and heights of extreme tides.

54. Read MS, MY, MD to determine if more problems are to be done. If MS, MY, and MD are all zero, all calculations are finished. If any of the three are not zero, more calculations are to follow. If MS is non-zero, new station cards are to be loaded. If MY is non-zero, new year cards are to be loaded. If MD is non-zero, a new date control card is to be loaded.

4. CONTROL CARDS

The data and control cards are arranged in the following order:

Cosines	(86 cards)
Constituent Speeds	(6 cards)
Title card	(1 card)
Station constants	(6 cards)
Datum plane, Output control word	(1 card)
Year constants	(5 cards)

98666 88666 99992 99994 99996 99997 99998 99998

XCOS (J)

289841742	377777777	284397295	150410686	139430356	149589314	300821373
-----------	-----------	-----------	-----------	-----------	-----------	-----------

A (J)

HAMPTON ROADS, VA. TIDE PREDICTIONS, 1968

TITLE

220	1	12192649	2352884	2712489	1731269	1361539	521243	592861
-----	---	----------	---------	---------	---------	---------	--------	--------

IST A- NO- (AMP(J).EPOC(J))

1252

DATUM, INC.

1968	1	1	96434691000	0	96428311110	7811783398100035031	307195411852158
------	---	---	-------------	---	-------------	---------------------	-----------------

IYR, LY-, NUM-, (XODE(J), VPU(J))

1-1312-110

MO(J),NB DAY(J),NEDAY(J)

MS MY, MD

[illegible]

618 : 0 319 6

Date control	(1 card)
Termination control	(1 card)

A sample of each type of card is shown in figure 2. The formats and card descriptions of the data and control words used in the program follow:

Cosine cards: XCOS(J)

(12F6.5) 1025 cosine values from 0 to $\pi/2$ at intervals of 90/1024 degrees. A listing of the cosines is presented as Appendix B.

Constituent Speeds cards: (A(J))

(7F10.7) 37 values of constituent speeds in degrees per hour.

Title card:

(72H) Any 72 Hollerith characters desired as the title line of output.

Station cards: ISTA_, NO., (AMP(J), EPOCH(J))

(2I4, F5.3, F4.1, F5.3, F4.1, F5.3, F4.1, F5.3, F4.1, F5.3, F4.1, F5.3, F4.1, F5.3, F4.1). The first two words on each of the six station cards are the station number and the card number which varies from 1 through 6. The remainder of each card consists of seven pairs of amplitudes (AMP(J)) in feet and phase angles (EPOCH(J)) in degrees for seven constituents.

Datum plane and output control card: DATUM, IND

(F6.3, I2) The datum plane (DATUM) is expressed in feet. The output control word (IND) indicates which calculations and output are desired. IND is punched 1 for high and low tides only, 2 for hourly values and high and low tides, and 3 for hourly values only.

Year cards: IYR_, LY_, NUM_, (XODE(J), VPU(J))

(I4, 2I2, F4.3, F4.1, F4.3, F4.1, F4.3, F4.1, F4.3, F4.1, F4.3, F4.1, F4.3, F4.1, F4.3, F4.1). The first three words on each of the five year cards are the year (IYR_), a word (LY_) which specifies if the year is a leap year, and the card number (NUM_). LY_ is punched 0 for a non-leap year and 1 for a leap year. The remainder of the card consists of eight pairs of amplitude modification factors (XODE(J)) and Greenwich equilibrium arguments (VPU(J)) in degrees.

Date control card: MO(J), NBDAY(J), NEDAY(J)

(36I2) Each time period for which calculations are to be made is specified by three words, the month number (MO(J)), the beginning date (NBDAY(J)), and the last date of the period (NEDAY(J)). Twelve time periods is the maximum number which can be specified on one date control card.

HAMPTON ROADS, VA. TIDE PREDICTIONS, 1968									
YEAR 1968	MONTH 3	DATUM	1.25	NO. OF CONSTITUENTS	15	CHECKSUM	-0.00000000		
1	2.0	1.4	0.7	0.1	-0.2	0.1	0.7	1.4	2.0
2	2.1	1.5	0.8	0.2	-0.3	0.0	0.5	1.2	2.3
3	2.2	1.6	0.9	0.3	-0.4	-0.1	0.4	1.0	2.1
4	2.3	1.7	1.0	0.4	-0.5	-0.2	0.3	0.8	2.0
5	2.4	1.8	1.1	0.5	-0.6	-0.3	0.2	0.6	1.7
6	2.5	1.9	1.2	0.6	-0.7	-0.4	0.1	0.5	1.4
7	2.6	2.0	1.3	0.7	-0.8	-0.5	0.0	0.4	1.3
8	2.7	2.1	1.4	0.8	-0.9	-0.6	0.0	0.3	1.0
9	2.8	2.2	1.5	0.9	-1.0	-0.7	0.0	0.2	0.8
10	2.9	2.3	1.6	1.0	-1.1	-0.8	0.0	0.1	0.6
11	3.0	2.4	1.7	1.1	-1.2	-0.9	0.0	0.0	0.5
12	3.1	2.5	1.8	1.2	-1.3	-1.0	0.0	0.0	0.4
13	3.2	2.6	1.9	1.3	-1.4	-1.1	0.0	0.0	0.3
14	3.3	2.7	2.0	1.4	-1.5	-1.2	0.0	0.0	0.2
15	3.4	2.8	2.1	1.5	-1.6	-1.3	0.0	0.0	0.1
16	3.5	2.9	2.2	1.6	-1.7	-1.4	0.0	0.0	0.0
17	3.6	3.0	2.3	1.7	-1.8	-1.5	0.0	0.0	0.0
18	3.7	3.1	2.4	1.8	-1.9	-1.6	0.0	0.0	0.0
19	3.8	3.2	2.5	1.9	-2.0	-1.7	0.0	0.0	0.0
20	3.9	3.3	2.6	2.0	-2.1	-1.8	0.0	0.0	0.0
21	4.0	3.4	2.7	2.1	-2.2	-1.9	0.0	0.0	0.0
22	4.1	3.5	2.8	2.2	-2.3	-2.0	0.0	0.0	0.0
23	4.2	3.6	2.9	2.3	-2.4	-2.1	0.0	0.0	0.0
24	4.3	3.7	3.0	2.4	-2.5	-2.2	0.0	0.0	0.0
25	4.4	3.8	3.1	2.5	-2.6	-2.3	0.0	0.0	0.0
26	4.5	3.9	3.2	2.6	-2.7	-2.4	0.0	0.0	0.0
27	4.6	4.0	3.3	2.7	-2.8	-2.5	0.0	0.0	0.0
28	4.7	4.1	3.4	2.8	-2.9	-2.6	0.0	0.0	0.0
29	4.8	4.2	3.5	2.9	-3.0	-2.7	0.0	0.0	0.0
30	4.9	4.3	3.6	3.0	-3.1	-2.8	0.0	0.0	0.0
31	5.0	4.4	3.7	3.1	-3.2	-2.9	0.0	0.0	0.0
32	5.1	4.5	3.8	3.2	-3.3	-3.0	0.0	0.0	0.0
33	5.2	4.6	3.9	3.3	-3.4	-3.1	0.0	0.0	0.0
34	5.3	4.7	4.0	3.4	-3.5	-3.2	0.0	0.0	0.0
35	5.4	4.8	4.1	3.5	-3.6	-3.3	0.0	0.0	0.0
36	5.5	4.9	4.2	3.6	-3.7	-3.4	0.0	0.0	0.0
37	5.6	5.0	4.3	3.7	-3.8	-3.5	0.0	0.0	0.0
38	5.7	5.1	4.4	3.8	-3.9	-3.6	0.0	0.0	0.0
39	5.8	5.2	4.5	3.9	-4.0	-3.7	0.0	0.0	0.0
40	5.9	5.3	4.6	4.0	-4.1	-3.8	0.0	0.0	0.0
41	6.0	5.4	4.7	4.1	-4.2	-3.9	0.0	0.0	0.0
42	6.1	5.5	4.8	4.2	-4.3	-4.0	0.0	0.0	0.0
43	6.2	5.6	4.9	4.3	-4.4	-4.1	0.0	0.0	0.0
44	6.3	5.7	5.0	4.4	-4.5	-4.2	0.0	0.0	0.0
45	6.4	5.8	5.1	4.5	-4.6	-4.3	0.0	0.0	0.0
46	6.5	5.9	5.2	4.6	-4.7	-4.4	0.0	0.0	0.0
47	6.6	6.0	5.3	4.7	-4.8	-4.5	0.0	0.0	0.0
48	6.7	6.1	5.4	4.8	-4.9	-4.6	0.0	0.0	0.0
49	6.8	6.2	5.5	4.9	-5.0	-4.7	0.0	0.0	0.0
50	6.9	6.3	5.6	5.0	-5.1	-4.8	0.0	0.0	0.0
51	7.0	6.4	5.7	5.1	-5.2	-4.9	0.0	0.0	0.0
52	7.1	6.5	5.8	5.2	-5.3	-5.0	0.0	0.0	0.0
53	7.2	6.6	5.9	5.3	-5.4	-5.1	0.0	0.0	0.0
54	7.3	6.7	6.0	5.4	-5.5	-5.2	0.0	0.0	0.0
55	7.4	6.8	6.1	5.5	-5.6	-5.3	0.0	0.0	0.0
56	7.5	6.9	6.2	5.6	-5.7	-5.4	0.0	0.0	0.0
57	7.6	7.0	6.3	5.7	-5.8	-5.5	0.0	0.0	0.0
58	7.7	7.1	6.4	5.8	-5.9	-5.6	0.0	0.0	0.0
59	7.8	7.2	6.5	5.9	-6.0	-5.7	0.0	0.0	0.0
60	7.9	7.3	6.6	6.0	-6.1	-5.8	0.0	0.0	0.0
61	8.0	7.4	6.7	6.1	-6.2	-5.9	0.0	0.0	0.0
62	8.1	7.5	6.8	6.2	-6.3	-6.0	0.0	0.0	0.0
63	8.2	7.6	6.9	6.3	-6.4	-6.1	0.0	0.0	0.0
64	8.3	7.7	7.0	6.4	-6.5	-6.2	0.0	0.0	0.0
65	8.4	7.8	7.1	6.5	-6.6	-6.3	0.0	0.0	0.0
66	8.5	7.9	7.2	6.6	-6.7	-6.4	0.0	0.0	0.0
67	8.6	8.0	7.3	6.7	-6.8	-6.5	0.0	0.0	0.0
68	8.7	8.1	7.4	6.8	-6.9	-6.6	0.0	0.0	0.0
69	8.8	8.2	7.5	6.9	-7.0	-6.7	0.0	0.0	0.0
70	8.9	8.3	7.6	7.0	-7.1	-6.8	0.0	0.0	0.0
71	9.0	8.4	7.7	7.1	-7.2	-6.9	0.0	0.0	0.0
72	9.1	8.5	7.8	7.2	-7.3	-7.0	0.0	0.0	0.0
73	9.2	8.6	7.9	7.3	-7.4	-7.1	0.0	0.0	0.0
74	9.3	8.7	8.0	7.4	-7.5	-7.2	0.0	0.0	0.0
75	9.4	8.8	8.1	7.5	-7.6	-7.3	0.0	0.0	0.0
76	9.5	8.9	8.2	7.6	-7.7	-7.4	0.0	0.0	0.0
77	9.6	9.0	8.3	7.7	-7.8	-7.5	0.0	0.0	0.0
78	9.7	9.1	8.4	7.8	-7.9	-7.6	0.0	0.0	0.0
79	9.8	9.2	8.5	7.9	-8.0	-7.7	0.0	0.0	0.0
80	9.9	9.3	8.6	8.0	-8.1	-7.8	0.0	0.0	0.0
81	10.0	9.4	8.7	8.1	-8.2	-7.9	0.0	0.0	0.0
82	10.1	9.5	8.8	8.2	-8.3	-8.0	0.0	0.0	0.0
83	10.2	9.6	8.9	8.3	-8.4	-8.1	0.0	0.0	0.0
84	10.3	9.7	9.0	8.4	-8.5	-8.2	0.0	0.0	0.0
85	10.4	9.8	9.1	8.5	-8.6	-8.3	0.0	0.0	0.0
86	10.5	9.9	9.2	8.6	-8.7	-8.4	0.0	0.0	0.0
87	10.6	10.0	9.3	8.7	-8.8	-8.5	0.0	0.0	0.0
88	10.7	10.1	9.4	8.8	-8.9	-8.6	0.0	0.0	0.0
89	10.8	10.2	9.5	8.9	-9.0	-8.7	0.0	0.0	0.0
90	10.9	10.3	9.6	9.0	-9.1	-8.8	0.0	0.0	0.0
91	11.0	10.4	9.7	9.1	-9.2	-8.9	0.0	0.0	0.0
92	11.1	10.5	9.8	9.2	-9.3	-9.0	0.0	0.0	0.0
93	11.2	10.6	9.9	9.3	-9.4	-9.1	0.0	0.0	0.0
94	11.3	10.7	10.0	9.4	-9.5	-9.2	0.0	0.0	0.0
95	11.4	10.8	10.1	9.5	-9.6	-9.3	0.0	0.0	0.0
96	11.5	10.9	10.2	9.6	-9.7	-9.4	0.0	0.0	0.0
97	11.6	11.0	10.3	9.7	-9.8	-9.5	0.0	0.0	0.0
98	11.7	11.1	10.4	9.8	-9.9	-9.6	0.0	0.0	0.0
99	11.8	11.2	10.5	9.9	-10.0	-9.7	0.0	0.0	0.0
100	11.9	11.3	10.6	10.0	-10.1	-9.8	0.0	0.0	0.0

HAMPTON ROADS, VA. TIDE PREDICTIONS, 1968
YEAR 1968 MONTH 3 DATUM 1.25 NO. OF CONSTITUENTS 15 CHECKSUM -0.00000000

TIMES AND HEIGHTS OF HIGH AND LOW WATERS

DAY	TIME	HT.	TIME	HT.	TIME	HT.	TIME	HT.	TIME	HT.
1	430	-0.3	1036	2.4	1642	-0.3	2300	2.5		
2	506	-0.2	1112	2.3	1718	-0.2	2336	2.4		
3	548	0.0	1142	2.1	1748	-0.1				
4	12	2.3	624	0.1	1218	2.0	1830	0.0		
5	54	2.2	706	0.3	1300	1.8	1906	0.1		
6	136	2.2	800	0.4	1348	1.7	1954	0.2		
7	230	2.1	854	0.4	1448	1.6	2048	0.3		
8	330	2.1	1000	0.4	1548	1.6	2154	0.3		
9	430	2.2	1100	0.3	1654	1.7	2300	0.2		
10	530	2.3	1200	0.2	1754	1.9				

Figure 3. - Samples of the printed output of the program. These printouts show (above) the calculated hourly tide and (below) the times and heights of high and low waters for Hampton Roads, Va. for March 1 - 10, 1968.

Termination control card: MS, MY, MD

(314) These three words determine if more problems are to be done. If all three are zero, no other problems will be done. If MS is punched 1, new station constants will be read. If MY is punched 1, new year constants will be read. If MD is punched 1, a new date control card will be read.

5. SAMPLES OF THE OUTPUT

A sample of each type of printed output is shown in figure 3. The top half of the figure is a set of hourly tide heights and the lower portion is a set of times and heights of high and low waters. The datum plane is 1.25 feet (which is mean low water at Hampton Roads) and 15 non-zero constituents were included in the calculations.

Each day of hourly tide heights requires two lines of printing. The first number of each line is the date of the month and the other twelve numbers are the hourly tide heights expressed in feet. The first line of each day contains heights from 0000 Local Standard Time (LST) to 1100 LST. The second line covers the period 1200 LST through 2300 LST.

The section of the output containing the highs and lows shows the time (LST) of high or low tide in hours and minutes with no separation or punctuation between hours and minutes. Heights are printed in feet. For example, figure 3 shows the first low tide on March 1 to be -0.3 ft. MLW at 0430 LST.

REFERENCES

1. D. L. Harris, N. A. Pore, and R. A. Cummings, "Tide and Tidal Current Prediction by High Speed Digital Computer," International Hydrographic Review, vol. XLII, No. 1, Jan. 1965, pp. 95-103.
2. P. Schureman, Manual of Harmonic Analysis and Prediction of Tides, Special Publication No. 98, U. S. Coast and Geodetic Survey, Washington, D. C., 1958, 317 pp.

APPENDIX A

Listing of FORTRAN IV source statements for Astronomical Tide Prediction Program as compiled on the IBM 7094.

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      DIMENSION A(40), AMP(40), EPOCH(40), XCODE(40), VPU(40), MO(13), SP(40),
1  NBDAY(13), NEDAY(13), XCOS(1026), SPD(40), ARG(40), TABHR(25),
2  ANG(40), KDAY(32), STORX(768), EXAM(400), JXTIM(200), XHT(200),
3  EPOCH(40), AMPA(40), XXHT(12), JJXT(12)
      DATA (TABHR(I), I=1,24) / -24., 720., 1392., 2136., 2856., 3600.,
1  4320., 5064., 5808., 6552., 7296., 8016., 8760., 9504., 10248., 10992.,
2  11736., 12480., 13224., 13968., 14712., 15456., 16200., 16944., 17688., 18432., 19176., 19920., 20664., 21408., 22152., 22896., 23640., 24384., 25128., 25872., 26616., 27360., 28104., 28848., 29592., 30336., 31080., 31824., 32568., 33312., 34056., 34800., 35544., 36288., 37032., 37776., 38520., 39264., 40008., 40752., 41496., 42240., 42984., 43728., 44472., 45216., 45960., 46704., 47448., 48192., 48936., 49680., 50424., 51168., 51912., 52656., 53400., 54144., 54888., 55632., 56376., 57120., 57864., 58608., 59352., 60096., 60840., 61584., 62328., 63072., 63816., 64560., 65304., 66048., 66792., 67536., 68280., 69024., 69768., 70512., 71256., 72000., 72744., 73488., 74232., 74976., 75720., 76464., 77208., 77952., 78696., 79440., 80184., 80928., 81672., 82416., 83160., 83904., 84648., 85392., 86136., 86880., 87624., 88368., 89112., 89856., 90600., 91344., 92088., 92832., 93576., 94320., 95064., 95808., 96552., 97296., 98040., 98784., 99528., 100272., 101016., 101760., 102504., 103248., 103992., 104736., 105480., 106224., 106968., 107712., 108456., 109200., 109944., 110688., 111432., 112176., 112920., 113664., 114408., 115152., 115896., 116640., 117384., 118128., 118872., 119616., 120360., 121104., 121848., 122592., 123336., 124080., 124824., 125568., 126312., 127056., 127800., 128544., 129288., 130032., 130776., 131520., 132264., 133008., 133752., 134496., 135240., 135984., 136728., 137472., 138216., 138960., 139704., 140448., 141192., 141936., 142680., 143424., 144168., 144912., 145656., 146400., 147144., 147888., 148632., 149376., 150120., 150864., 151608., 152352., 153096., 153840., 154584., 155328., 156072., 156816., 157560., 158304., 159048., 159792., 160536., 161280., 162024., 162768., 163512., 164256., 165000., 165744., 166488., 167232., 167976., 168720., 169464., 170208., 170952., 171696., 172440., 173184., 173928., 174672., 175416., 176160., 176904., 177648., 178392., 179136., 179880., 180624., 181368., 182112., 182856., 183600., 184344., 185088., 185832., 186576., 187320., 188064., 188808., 189552., 190296., 191040., 191784., 192528., 193272., 194016., 194760., 195504., 196248., 196992., 197736., 198480., 199224., 199968., 200712., 201456., 202200., 202944., 203688., 204432., 205176., 205920., 206664., 207408., 208152., 208896., 209640., 210384., 211128., 211872., 212616., 213360., 214104., 214848., 215592., 216336., 217080., 217824., 218568., 219312., 220056., 220800., 221544., 222288., 223032., 223776., 224520., 225264., 226008., 226752., 227496., 228240., 228984., 229728., 230472., 231216., 231960., 232704., 233448., 234192., 234936., 235680., 236424., 237168., 237912., 238656., 239400., 240144., 240888., 241632., 242376., 243120., 243864., 244608., 245352., 246096., 246840., 247584., 248328., 249072., 249816., 250560., 251304., 252048., 252792., 253536., 254280., 255024., 255768., 256512., 257256., 258000., 258744., 259488., 260232., 260976., 261720., 262464., 263208., 263952., 264696., 265440., 266184., 266928., 267672., 268416., 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      READ (5,535) (XCOS(J), J = 1,1026)
      MS = 1
      MY = 1
      MD = 1
      CON = 1024. / 90.
      READ (5,530) (A(J), J = 1,37)
      DO 90 J = 1,37
90  A(J) = A(J) * CON
100 IF (MS.EQ.0) GO TO 120
110 READ (5,530)
      READ (5,531) ISTA1,NO1,(AMP(J),EPOCH(J),J=1,7),ISTA2,NO2,(AMP(J),
1  EPOCH(J),J=8,14),ISTA3,NO3,(AMP(J),EPOCH(J),J=15,21),ISTA4,NO4,
2  (AMP(J),EPOCH(J),J=22,28),ISTA5,NO5,(AMP(J),EPOCH(J),J=29,35),
3  ISTA6,NO6,(AMP(J),EPOCH(J),J=36,40)
      IF (ISTA1.NE. ISTA2) GO TO 451
      IF (ISTA2.NE. ISTA3) GO TO 451
      IF (ISTA3.NE. ISTA4) GO TO 451
      IF (ISTA4.NE. ISTA5) GO TO 451
      IF (ISTA5.NE. ISTA6) GO TO 451
      IF (NO1.NE. 1) GO TO 450
      IF (NO2.NE. 2) GO TO 450
      IF (NO3.NE. 3) GO TO 450
      IF (NO4.NE. 4) GO TO 450
      IF (NO5.NE. 5) GO TO 450
      IF (NO6.NE. 6) GO TO 450
119 READ (5,532) DATUM,IND
120 IF (MY.EQ.0) GO TO 131
130 READ (5,533) IYR1,LY1,NUM1,(XCODE(J),VPU(J), J = 1,8), IYR2,LY2,
1  NUM2,(XCODE(J),VPU(J), J=9,16), IYR3,LY3,NUM3,(XCODE(J),
2  VPU(J),J = 17,24), IYR4,LY4,NUM4,(XCODE(J),VPU(J), J = 25,32),
3  IYR5,LY5,NUM5,(XCODE(J),VPU(J), J = 33,40)
      IF (IYR1.NE. IYR2) GO TO 452
      IF (IYR2.NE. IYR3) GO TO 452
      IF (IYR3.NE. IYR4) GO TO 452
      IF (IYR4.NE. IYR5) GO TO 452
      IF (NUM1.NE. 1) GO TO 453
      IF (NUM2.NE. 2) GO TO 453
      IF (NUM3.NE. 3) GO TO 453
      IF (NUM4.NE. 4) GO TO 453
      IF (NUM5.NE. 5) GO TO 453
131 IF (MD.EQ.0) GO TO 160
140 READ (5,534) (MO(J),NBDAY(J),NEDAY(J), J = 1,12)
      SET UP TABLES FOR NON-ZERO CONSTITUENTS
      K = 0
      DO 180 J = 1,40
161 IF (AMP(J).EQ.0.0) GO TO 180
170 K = K + 1
      AMPA(K) = AMP(J) * XCODE(J)
      TEMX = VPU(J) - EPOCH(J)
      IF (TEMX.GE. 0.) GO TO 171
      TEMX = TEMX + 360.
171 EPOCH(K) = TEMX * CON
      SPD(K) = A(J)
      SP(K) = SPD(K) / 10.
180 CONTINUE
      NOCON = K
      OPERATING TABLES NOW STORED AS AMPA(K),EPOCH(K),SPD(K)
      DO 2000 JP = 1,12
      MO(13) = MO(JP)
      NBDAY(13) = NBDAY(JP)
      NEDAY(13) = NEDAY(JP)
      NNEDA = NEDAY(13) + 1
181 IF (MO(13).EQ.0) GO TO 3005
190 NODAYS = NEDAY(13) - NBDAY(13) + 2
      NOHRS = NODAYS * 24
      HRS = NOHRS
      DETERMINE FIRST HOUR OF TIME PERIOD
191 IF (LY1.GT.0) GO TO 210
200 K = MO(13)
      GO TO 215
210 K = MO(13) + 12

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215 BDAY = NBDAY(13)
    FIRST = TABHR(K) + BDAY * 24.
    NEIRST = FIRST
    DO 220 J = 1,769
220 STORX(J) = 0.
C TIDE = DATUM + AMPA(K) * COS(A(K) * T + EPOCH(K))
    KOUNT = 0
    KT = 0
    DO 380 K = 1,NOHRS
221 IF (KOUNT.GT.0) GO TO 260
230 KOUNT = 1
231 DO 250 J = 1,NOCON
    ARGU = SPD(J) * FIRST + EPOCH(J)
250 ARG(J) = AMOD(ARGU,4096.)
    GO TO 290
260 DO 280 J = 1,NOCON
    ARG(J) = ARG(J) + SPD(J)
270 IF (ARG(J).LT.4096.) GO TO 280
    ARG(J) = ARG(J) - 4096.
    GO TO 270
280 CONTINUE
290 DO 374 J = 1,NOCON
    IF (ARG(J) - 1024.) 320,320,300
300 IF (ARG(J) - 2048.) 350,350,310
310 IF (ARG(J) - 3072.) 360,360,330
320 ANG(J) = ARG(J)
    GO TO 340
330 ANG(J) = 4096. - ARG(J)
340 NP = ANG(J) + 1.5
    STORX(K) = STORX(K) + AMPA(J) * XCOS(NP)
    GO TO 374
350 ANG(J) = 2048. - ARG(J)
    GO TO 370
360 ANG(J) = ARG(J) - 2048.
370 NP = ANG(J) + 1.5
    STORX(K) = STORX(K) - AMPA(J) * XCOS(NP)
374 CONTINUE
275 IF (K.NE.NOHRS) GO TO 380
376 IF (KT.EQ.1) GO TO 378
    FIRST = FIRST + HRS - 1.
    KT = 1
    CHECK = STORX(K)
    STORX(K) = 0.
    GO TO 231
378 CKSUM = CHECK - STORX(K)
380 CONTINUE
    DO 400 K = 1,NOHRS
400 STORX(K) = STORX(K) + DATUM
    GO TO (419,401,401),IND
401 KDAY(1) = NBDAY(13)
    NODAYS = NODAYS - 1
    DO 410 I = 2,NODAYS
410 KDAY(I) = KDAY(I-1) + 1
    WRITE (6,550)
    WRITE (6,560) IYR1,MO(13),DATUM,NOCON,CKSUM
    WRITE (6,537) (KDAY(I), STORX(24*I-23), STORX(24*I-22), STORX(24*I-
1-21), STORX(24*I-20), STORX(24*I-19), STORX(24*I-18), STORX(24*I-
2-17), STORX(24*I-16), STORX(24*I-15), STORX(24*I-14), STORX(24*I-
3-13), STORX(24*I-12), KDAY(1), STORX(24*I-11), STORX(24*I-10),
4 STORX(24*I-9), STORX(24*I-8), STORX(24*I-7), STORX(24*I-6),
5 STORX(24*I-5), STORX(24*I-4), STORX(24*I-3), STORX(24*I-2),
6 STORX(24*I-1), STORX(24*I), I=1,NODAYS)
419 IF (IND.EQ.3) GO TO 2000
    GO TO 1000
450 WRITE (6,501)
    STOP
451 WRITE (6,502)
    STOP
452 WRITE (6,503)
    STOP
453 WRITE (6,504)
    STOP
501 FORMAT (27H STATION CARDS OUT OF ORDER)
502 FORMAT (31H STATION NUMBERS NOT CONSISTENT)
503 FORMAT (28H YEAR NUMBERS NOT CONSISTENT)
504 FORMAT (24H YEAR CARDS OUT OF ORDER)
530 FORMAT (7F10.7)
531 FORMAT (2I4,F5.3,F4.1,F5.3,F4.1,F5.3,F4.1,F5.3,F4.1,F5.3,F4.1)

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1 F5.3,F4.1,F5.3,F4.1)
532 FORMAT (F6.3,12)
533 FORMAT (14,212,F4.3,F4.1,F4.3,F4.1,F4.3,F4.1,F4.3,F4.1,
1 F4.3,F4.1,F4.3,F4.1,F4.3,F4.1,F4.3,F4.1)
534 FORMAT (3612)
535 FORMAT (12F6.5)
537 FORMAT (19,12F9.1)
538 FORMAT (314)
550 FORMAT (72H)
1
560 FORMAT (6H YEAR ,14,7H MONTH,13,9H DATUM ,F7.2, 24H NO. OF
1 CONSTITUENTS ,14,13H CHECKSUM,F12.7//)
575 FORMAT (//41H TIMES AND HEIGHTS OF HIGH AND LOW WATERS//)
580 FORMAT (112H DAY TIME HT. TIME HT. TIME HT. TIME HT.)
1 HT. TIME HT. TIME HT. TIME HT.
581 FORMAT (28H CONSECUTIVE TIDES SAME TIME)
585 FORMAT (1H0,19,6(5X14,F8.1)/10X,6(5X14,F8.1))
C COMPUTE TIMES AND HEIGHTS OF HIGH AND LOW WATERS
1000 ITEMS = 0
1010 K = 1
NOHRS = NOHRS - 1
1035 DO 1500 I = 1,NOHRS
IF (I.EQ.1) GO TO 1039
1038 GO TO (1270,1287),NST
1039 NWHOA = 7
TIME = NFIRST * 10
NARC = 1
GO TO 1060
1040 IF (STORX(I) - STORX(I+1)) 1285,1045,1265
1045 NWHOA = 1
NARC = 1
TIME = NFIRST * 10
GO TO 1060
1050 TIME = (NFIRST + I - 2) * 10
NARC = 1
1060 STORX = DATUM
GO TO (1075,1100),NARC
1075 DO 1090 J = 1,NUCCN
ARGU = SP(J) * TIME + EPOCH(J)
1090 ARG(J) = AMOD(ARGU,4096.)
GO TO 1120
1100 DO 1110 J = 1,NUCCN
ARG(J) = ARG(J) + SP(J)
1105 IF (ARG(J).LT.4096.) GO TO 1110
ARG(J) = ARG(J) - 4096.
GO TO 1105
1110 CONTINUE
1120 DO 1220 J = 1,NUCCN
IF (ARG(J) - 1024.) 1150,1150,1150
1130 IF (ARG(J) - 2048.) 1180,1180,1140
1140 IF (ARG(J) - 3072.) 1190,1190,1160
1150 ANG(J) = ARG(J)
GO TO 1170
1160 ANG(J) = 4096. - ARG(J)
1170 NP = ANG(J) + 1.5
STORX = STORX + AMPA(J) * XCOS(NP)
GO TO 1220
1180 ANG(J) = 2048. - ARG(J)
GO TO 1200
1190 ANG(J) = ARG(J) - 2048.
1200 NP = ANG(J) + 1.5
1210 STORX = STORX - AMPA(J) * XCOS(NP)
1220 CONTINUE
GO TO (1250,1260,1275,1280,1290,1295,1400,1410,1412), NWHOA
1250 POINT1 = STORX
NWHOA = 2
NARC = 2
GO TO 1060
1260 IF (POINT1 - STORX) 1285,1060,1265
1265 NWHOA = 3
NST = 1
1270 IF (STORX(I) - STORX(I+1)) 1050,1050,1500
1275 POINT1 = STORX
JHOL = 1
NWHOA = 4
NARC = 2
TIME = TIME + 1.
GO TO 1060

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1280	IF (POINT1 - STOXR) 1425,1425,1300	42
1285	NWHOA = 5 NST = 2	43
1287	IF (STORX(I) - STORX(I+1)) 1500,1050,1050	44
1290	POINT1 = STOXR JHOL = 2 NWHOA = 6 NARC = 2 TIME = TIME + 1. GO TO 1060	
1295	IF (POINT1 - STOXR) 1300,1425,1425	45
1300	TIME = TIME + 1. POINT1 = STOXR GO TO 1060	
1400	POINT1 = STOXR NWHOA = 8 NARC = 2 TIME = TIME + 1. GO TO 1060	
1410	IF (POINT1-STOXR) 1415,1411,1420	
1411	NWHOA = 9 POINT2 = STOXR GO TO 1060	46
1412	IF (POINT2-STOXR) 1413,1040,1414	
1413	JHOL = 1 GO TO 1425	
1414	JHOL = 2 GO TO 1425	
1415	IF (STOXR - STORX(I+1)) 1285,1290,1290	
1420	IF (STOXR - STORX(I+1)) 1275,1275,1265	
1425	EXTIM(K) = TIME - 1. EXTIM(K+1) = POINT1 IF (K.EQ.1) GO TO 1430 IF (EXTIM(K).GT.EXTIM(K-2)) GO TO 1430 GO TO 1300	47
1430	K = K + 2 ITEMS = ITEMS + 2 GO TO (1285,1265),JHOL	48
1500	CONTINUE KAY = ITEMS / 2 J = 0 DO 1650 K = 1,ITEMS,2 J = J + 1	49
	JHR = EXTIM(K) JHR = MOD(JHR,240) JTEN = MOD(JHR,10) JXTIM(J) = ((JHR - JTEN) * 10) + JTEN * 6 XHT(J) = EXTIM(K+1)	
1600	IF (XHT(J)) 1600,1650,1650 IF (XHT(J).LE.-0.05) GO TO 1650 XHT(J) = -XHT(J)	50
1650	CONTINUE	
1670	NDAY = NBDAY(13) NCOUNT = 0 NNJ = 1	51
1674	WRITE (6,550) WRITE (6,560) IYR1,MO(13),DATUM,NOCON,CKSUM WRITE (6,575) WRITE (6,580)	52
1704	DO 1750 I = 1,KAY IF (JXTIM(I) - JXTIM(I+1)) 1705,1710,1715	
1705	NCOUNT = NCOUNT + 1 GO TO 1750	
1710	WRITE (6,581)	
1715	STOP	
1717	NLAST = NNJ + NCOUNT WRITE (6,585) NDAY,(JXTIM(J),XHT(J), J = NNJ,NLAST)	53
1740	NNJ = NLAST + 1 NCOUNT = 0 NDAY = NDAY + 1	
1745	IF (NDAY.EQ.NNEDA) GO TO 2000	
1750	CONTINUE	
2000	CONTINUE	
2005	READ (5,538) MS,MY,MD	54
2010	IF (MS+MY+MD) 2020,2020,100	
2020	STOP END	

APPENDIX B

Cosine table for use in the Astronomical Tide Program. The format is (12F6.5). The 1025 cosines are in order from 0° to 90° at intervals of $90/1024$ degrees. The decimal points need not be punched; they are shown here for clarity.

COSINES

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1.00000	.99999	.99999	.99999	.99998	.99997	.99996	.99994	.99992	.99990	.99988	.99986
.99983	.99980	.99977	.99974	.99970	.99966	.99962	.99958	.99953	.99948	.99943	.99938
.99932	.99927	.99922	.99914	.99908	.99901	.99894	.99887	.99879	.99872	.99864	.99856
.99848	.99839	.99830	.99821	.99812	.99802	.99793	.99782	.99772	.99762	.99751	.99740
.99729	.99717	.99706	.99694	.99682	.99670	.99657	.99644	.99631	.99618	.99604	.99591
.99577	.99562	.99548	.99534	.99518	.99503	.99488	.99472	.99457	.99441	.99424	.99408
.99391	.99373	.99357	.99339	.99321	.99303	.99284	.99266	.99248	.99228	.99210	.99191
.99170	.99151	.99131	.99110	.99090	.99070	.99048	.99027	.99006	.98984	.98962	.98940
.98917	.98895	.98873	.98849	.98826	.98803	.98778	.98754	.98731	.98705	.98681	.98657
.98630	.98605	.98580	.98553	.98528	.98502	.98474	.98448	.98422	.98393	.98366	.98339
.98310	.98283	.98255	.98225	.98197	.98168	.98138	.98109	.98079	.98048	.98019	.97987
.97957	.97926	.97894	.97863	.97832	.97799	.97768	.97736	.97702	.97670	.97638	.97603
.97570	.97537	.97502	.97468	.97435	.97398	.97364	.97330	.97293	.97258	.97223	.97186
.97150	.97115	.97076	.97040	.97004	.96965	.96928	.96891	.96852	.96814	.96776	.96736
.96698	.96660	.96618	.96580	.96541	.96500	.96459	.96420	.96377	.96337	.96297	.96253
.96213	.96169	.96128	.96086	.96042	.96000	.95958	.95913	.95870	.95827	.95781	.95738
.95695	.95648	.95604	.95560	.95513	.95468	.95424	.95376	.95330	.95285	.95236	.95191
.95144	.95095	.95049	.94902	.94852	.94805	.94757	.94707	.94659	.94611	.94569	.94511
.94462	.94410	.94361	.94311	.94259	.94205	.94155	.94104	.94050	.93999	.93947	.93893
.93839	.93784	.93731	.93678	.93625	.93572	.93519	.93462	.93409	.93355	.93298	.93244
.93189	.93131	.93076	.93021	.92963	.92907	.92852	.92792	.92736	.92680	.92620	.92563
.92505	.92445	.92388	.92330	.92269	.92211	.92153	.92091	.92032	.91973	.91910	.91851
.91792	.91728	.91668	.91608	.91544	.91483	.91423	.91358	.91297	.91235	.91170	.91108
.91046	.90980	.90917	.90855	.90788	.90725	.90657	.90594	.90530	.90462	.90398	.90334
.90265	.90201	.90136	.90066	.89901	.89836	.89766	.89690	.89618	.89546	.89473	.89398
.89324	.89248	.89174	.89098	.89018	.88938	.88857	.88775	.88692	.88608	.88523	.88438
.88351	.88265	.88179	.88092	.88004	.87915	.87826	.87736	.87645	.87553	.87461	.87368
.87274	.87181	.87087	.86992	.86897	.86801	.86705	.86608	.86511	.86414	.86316	.86218
.86119	.86021	.85922	.85823	.85723	.85623	.85522	.85421	.85319	.85217	.85115	.85012
.84909	.84806	.84702	.84598	.84493	.84387	.84281	.84174	.84067	.83959	.83851	.83743
.83634	.83525	.83416	.83306	.83195	.83084	.82972	.82860	.82747	.82634	.82520	.82407
.82293	.82179	.82064	.81948	.81832	.81715	.81598	.81480	.81362	.81244	.81125	.81006
.80887	.80767	.80647	.80526	.80404	.80282	.80159	.80036	.79912	.79788	.79663	.79538
.79412	.79286	.79159	.79031	.78903	.78774	.78644	.78514	.78383	.78251	.78119	.77986
.77853	.77719	.77584	.77448	.77311	.77174	.77036	.76897	.76758	.76618	.76478	.76337
.76196	.76054	.75911	.75768	.75624	.75479	.75334	.75188	.75041	.74894	.74746	.74598
.74449	.74299	.74149	.73998	.73846	.73693	.73539	.73385	.73230	.73074	.72918	.72761
.72604	.72446	.72288	.72129	.71969	.71809	.71648	.71486	.71324	.71161	.70997	.70833
.70668	.70503	.70337	.70170	.69992	.69814	.69635	.69455	.69274	.69092	.68909	.68725
.68541	.68356	.68170	.67983	.67795	.67606	.67416	.67225	.67033	.66840	.66646	.66451
.66255	.66060	.65864	.65667	.65469	.65270	.65070	.64869	.64666	.64463	.64258	.64053
.63847	.63640	.63432	.63223	.63013	.62802	.62590	.62377	.62163	.61948	.61732	.61515
.61297	.61079	.60860	.60640	.60419	.60197	.59974	.59750	.59525	.59299	.59072	.58844
.58615	.58386	.58155	.57923	.57690	.57456	.57221	.56985	.56748	.56510	.56271	.56031
.55791	.55549	.55306	.55062	.54817	.54571	.54324	.54076	.53827	.53577	.53326	.53074
.52821	.52568	.52313	.52057	.51800	.51542	.51283	.51023	.50762	.50500	.50237	.50000
.49751	.49490	.49228	.48964	.48699	.48433	.48166	.47898	.47629	.47359	.47088	.46816
.46543	.46269	.45994	.45718	.45441	.45163	.44884	.44604	.44323	.44041	.43758	.43474
.43189	.42904	.42618	.42331	.42043	.41754	.41464	.41173	.40881	.40588	.40294	.40000
.39705	.39410	.39114	.38817	.38519	.38220	.37920	.37619	.37317	.37014	.36710	.36405
.36100	.35794	.35487	.35179	.34870	.34560	.34249	.33937	.33624	.33310	.32995	.32679
.32362	.32044	.31725	.31405	.31084	.30762	.30439	.30115	.29790	.29464	.29137	.28810
.28482	.28153	.27823	.27492	.27159	.26825	.26490	.26154	.25817	.25479	.25140	.24799
.24457	.24114	.23770	.23425	.23079	.22732	.22384	.22035	.21685	.21333	.20980	.20625
.20269	.19912	.19553	.19193	.18831	.18468	.18103	.17737	.17369	.16999	.16628	.16255
.15881	.15500	.15117	.14732	.14345	.13956	.13565	.13172	.12777	.12380	.11981	.11580
.11177	.10773	.10368	.99922	.96474	.93025	.89576	.86127	.82678	.79229	.75780	.72331
.68882	.65433	.61984	.58535	.55086	.51637	.48188	.44739	.41290	.37841	.34392	.30943
.27494	.24045	.20596	.17147	.13698	.10249	.68999	.35750	.02501	.-0.30748	.-0.61495	.-0.91442
.-0.99989	.-0.99991	.-0.99993	.-0.99995	.-0.99996	.-0.99997	.-0.99998	.-0.99999	.-0.99999	.-0.99999	.-0.99999	.-0.99999

