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 programed 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:

\[ h = H_0 + \sum_{n=1}^{N} H_n \cos [a_n t + (V_n + u)_n - \phi_n], \]

(1)

h=1
where

\[ h = \text{height of tide at any time } t. \]

\[ H_0 = \text{mean height of water level above datum used for prediction.} \]

\[ H_n = \text{mean amplitude of any constituent } A_n. \]

\[ f_n = \text{factor for reducing mean amplitude to year of prediction.} \]

\[ a_n = \text{hourly speed of constituent } A_n. \]

\[ t = \text{time, in hours, reckoned from beginning of year of prediction.} \]

\[ (V_0 + u)_n = \text{Greenwich equilibrium argument of constituent } A_n \text{ when } t=0. \]

\[ K'_n = \text{modified epoch of constituent } A_n. \]

\[ N = \text{number of constituents used for the particular station.} \]

The cosines of the argument \([a_n \cdot t + (V_0 + u)_n - K'_n]\) 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 \(\text{AMP(J)}\), and the modified epoch of each constituent \(\text{EPOCH(J)}\) 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
\[ h_t = H_0 + \sum_{n=1}^{N} f_n h_n \cos \left[ a_n t + (V_o + u) h_n - K'_n \right] \]

**START**

**INCREASE** \( n \) **BY 1**

**IS AMPLITUDE** \( f_n \) **= 0?**

**YES**

**NO**

**INCREASE** \( k \) **BY 1**

**FORM PRODUCT** \( f_n h_n \) \(_k\)

**FORM** \( (V_o + u) h_n - K'_n \) \(_k\)

**SAVE** **CORRESPONDING** \( a_n \) as \( (a_n)_k \)

**ARE ALL CONSTITUENTS** **CONSIDERED?**

**YES**

**NO**

**IS YEAR A** **LEAP YEAR?**

**YES**

**INITIALIZE** **FOR LEAP YR.**

**DETERMINE** **HOUR NO.** **OF FIRST HOUR**

**K = 1**

**DETERMINE** **PHASE** **OF** **CONSTITUENT** \( k \) **FOR** **FIRST HOUR**

\[ a_n t + (V_o + u) h_n - K'_n \] \(_k\)

**ARE ALL CONSTITUENTS** **CONSIDERED?**

**NO**

**YES**

**INCREASE** \( k \) **BY 1**

**SUM ALL CONSTITUENTS** **& ADD** **DATUM** \( H_0 \)

**STORE** **AS** \( h_t \)

**ARE ALL CALCULATIONS** **MADE?**

**NO**

**YES**

**FOR NEXT HOUR TIME IS INCREASED** **BY 1** **SO ADD** \( (a_n)_k \) **TO PHASE OF EACH CONSTITUENT**

**RECOMPUTE** **LAST** **HOUR TIDE HEIGHT** **INDEPENDENTLY USING** **SAME** **METHOD** **AS** **FOR FIRST HOUR COMPUTATION**

**STORE** **DIFFERENCE** **BETWEEN** **THE** **TWO** **CALCULATED** **TIDE** **HEIGHTS** **FOR** **LAST** **HOUR.** **THIS** **DIFFERENCE** **SHOULD** **BE** **ZERO. ** **IF** **NOT** **THERE** **HAS** **BEEN** **A** **MALFUNCTION.**

**ARE** **CALCULATIONS** **FOR** **OTHER** **STATIONS** **OR** **PERIODS** **TO** **BE** **MADE?**

**NO**

**YES**

**LOAD** **NEW** **STATION** **OR** **YEAR** **CONSTITUENT** **CONSTANTS** **OR** **NEW** **DATE** **CONTROLS**

**PRINT OUTPUT**

**END**

---

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** $t_1$ **and** $t_1+1$ **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 (VP(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, NB(DAY(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), NB(DAY(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, h, in equation 1, EPOCH(K) which is V + u - K, in equation 1, and SPB(K) which is a, 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 $2\pi$.

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 $2\pi$.

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:

<table>
<thead>
<tr>
<th>Card Type</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cosines</td>
<td>86</td>
</tr>
<tr>
<td>Constituent Speeds</td>
<td>6</td>
</tr>
<tr>
<td>Title card</td>
<td>1</td>
</tr>
<tr>
<td>Station constants</td>
<td>6</td>
</tr>
<tr>
<td>Datum plane, Output control word</td>
<td>1</td>
</tr>
<tr>
<td>Year constants</td>
<td>5</td>
</tr>
</tbody>
</table>
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). 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). 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.
### Tide Predictions, 1968

<table>
<thead>
<tr>
<th>YEAR 1968</th>
<th>MONTH</th>
<th>DATUM</th>
<th>1.25</th>
<th>NO. OF CONSTITUENTS</th>
<th>15</th>
<th>CHECKSUM -0.0000000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.0</td>
<td>1.4</td>
<td>0.7</td>
<td>0.1</td>
<td>-0.2</td>
<td>-0.2</td>
</tr>
<tr>
<td>1</td>
<td>2.1</td>
<td>1.5</td>
<td>0.8</td>
<td>0.1</td>
<td>-0.2</td>
<td>-0.3</td>
</tr>
<tr>
<td>2</td>
<td>2.3</td>
<td>1.8</td>
<td>1.2</td>
<td>0.5</td>
<td>0.1</td>
<td>-0.1</td>
</tr>
<tr>
<td>2</td>
<td>2.7</td>
<td>1.8</td>
<td>1.2</td>
<td>0.6</td>
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<td>-0.2</td>
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<td>2.1</td>
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<td>0.4</td>
<td>0.1</td>
<td>-0.3</td>
</tr>
<tr>
<td>3</td>
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<td>1.5</td>
<td>0.9</td>
<td>0.4</td>
<td>0.0</td>
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<tr>
<td>4</td>
<td>2.3</td>
<td>2.2</td>
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<td>1.4</td>
<td>0.8</td>
<td>0.4</td>
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<tr>
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<td>1.9</td>
<td>1.6</td>
<td>1.2</td>
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</tr>
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<td>1.7</td>
<td>1.2</td>
<td>0.8</td>
</tr>
<tr>
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<td>1.7</td>
<td>1.4</td>
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</tr>
<tr>
<td>6</td>
<td>1.9</td>
<td>2.1</td>
<td>2.2</td>
<td>2.0</td>
<td>1.6</td>
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<td>1.6</td>
<td>1.5</td>
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<tr>
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</table>

### Times and Heights of High and Low Waters

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<tr>
<th>DAY</th>
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<th>HT.</th>
<th>TIME</th>
<th>HT.</th>
<th>TIME</th>
<th>HT.</th>
<th>TIME</th>
<th>HT.</th>
<th>TIME</th>
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</tr>
<tr>
<td>2</td>
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<td>0.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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


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

```
100 IE = IM*EP + 100 GO TO 120
110 READ (5, 531) (AI(J), J = 1, 37)
120 DO 20 J = 1, 37
130 READ (5, 533) (YR(J), J = 1, 38) GO TO 160
140 IF (MD% = 0) GO TO 160
150 IF (MD% = 1) READ (5, 533) (NUMS(J), J = 1, 12)
160 IF (IE = 1) GO TO 140
170 IF (AI(I) > 0.0) GO TO 180
180 NDAYA(J) = NDAYA(J) + 1
190 GO TO 200
200 CONTINUE
```

215  D DAY = N DAY(I3)  
220  STORX(J) = 0  
225  KOUNT = 0  
230  J = 1  
235  IF (KOUNT  .GT. 1) GO TO 260  
240  IF (ARG(J) .LT. 1024) ARG(J) = ARG(J) + 1024  
245  IF (ARG(J)  .GT. 4096) ARG(J) = ARG(J) - 4096  
250  GO TO 290  
255  NT = ARG(J)  
260  IF (ARG(J)  .LT. 1024) NT = NT + 1024  
265  IF (ARG(J) .GT. 4096) ARG(J) = ARG(J) - 4096  
270  GO TO 280  
275  CONTINUE  
280  J = 1  
285  IF (ARG(J) .LT. 1024) ARG(J) = ARG(J) + 1024  
290  IF (ARG(J) .GT. 4096) ARG(J) = ARG(J) - 4096  
295  GO TO 300  
300  CONTINUE  
305  ARG(J) = 1024  
310  ARG(J) = ARG(J) + 1024  
315  IF (ARG(J) .GT. 4096) ARG(J) = ARG(J) - 4096  
320  GO TO 325  
325  CONTINUE  
330  NT = ARG(J)  
335  IF (ARG(J) .LT. 1024) NT = NT + 1024  
340  IF (ARG(J) .GT. 4096) ARG(J) = ARG(J) - 4096  
345  GO TO 350  
350  ARG(J) = 2048  
355  IF (ARG(J) .LT. 1024) ARG(J) = ARG(J) + 1024  
360  IF (ARG(J) .GT. 4096) ARG(J) = ARG(J) - 4096  
365  GO TO 370  
370  CONTINUE  
375  IF (KON  .LT. 1) KON = 1  
380  IF (KON  .GT. 11) KON = 11  
385  WRITE (1) KON  
390  CONTINUE  
400  STORX(K) = STORX(K) + DATUM  
405  IF (KON  .LT. 1) KON = 1  
410  WRITE (1) KON  
415  WRITE (1) KON  
420  WRITE (6)  
425  STOP  
430  WRITE (6)  
435  STOP
1010   NOHRS = NOHRS - 1
1020   DO 1500 I = 1,NOHRS
1030   IF (I .EQ. 1) GO TO 1049
1035   GO TO (1270,1281)NST
1040   NINFO = NFIRST + 10
1045   NARC = 1
1050   IF( (STOKXX(I)) .LT. 4096) GO TO 1110
1055   ARGU = ARU(J) + 4096
1060   GO TO 1110
1065   STOKX = DATUM
1070   GO TO (1075,1100)NARC
1075   DO 1220 J = 1,NCCN
1080   ARGU = SP(J) + TIME + SPUC(J)
1090   ARG(J) = AR(ARU(J)) + SP(J)
1100   IF (ARG(J) .LT. 4096) GO TO 1110
1105   ARG(J) = ARG(J) - 4096
1110   GO TO 1120
1115   CONTINUE
1120   DO 1220 J = 1,NCCN
1125   IF (ARG(J) .EQ. 1024) 1125,1130,1135
1130   IF (ARG(J) .LE. 2048) 1125,1130,1140
1135   IF (ARG(J) .GT. 2047) 1125,1130,1140
1140   AN(J) = ARCT(J)
1145   GO TO 1170
1150   AN(J) = 4096 - AN(J)
1155   NP = AN(J) + 1.5
1160   STOKX = STOKX + AN(J) * XCUS(NP)
1165   GO TO 1220
1170   AN(J) = 2048 + AN(J)
1175   GO TO 1220
1180   AN(J) = 2048 - AN(J)
1185   GO TO 1220
1190   AN(J) = AR(J) + 2048
1195   NP = AN(J)
1200   AN(J) = 1.5
1205   STOKX = STOKX + AN(J) * XCUS(NP)
1210   CONTINUE
1215   GO TO (1250,1260,1275,1280,1290,1300,1400,1410,1420)NINFO
1220   CONTINUE
1225   POINT1 = STOKX
1230   NWGCA = 2
1235   NARC = 2
1240   IF (POINT1 .EQ. STOKX) 1260,1270,1280
1245   IF (POINT2 .EQ. STOKR) 1260,1270,1280
1250   JHOL = 1
1255   NWGCA = 4
1260   NARC = 2
1265   TIME = TIME + 1.
1270   GO TO 1060
1285 IF (POINT1 - STOXR) 1425, 1425, 1300
    XNOHA = 5
1287 IF (STORX(1)) - STORX(1+1)) 1500, 1050, 1050
1290 POINT1 = STORX
   JHOL = 2
   XNOHA = 6
   XARC = 2
   TIME = TIME + 1.
   GO TO 1060.
1295 IF (POINT1 - STORX) 1300, 1425, 1425
1300 TIME = TIME + 1.
   POINT1 = STORX
   GO TO 1060.
1400 POINT1 = STORX
   XNOHA = 8
   XARC = 2
   TIME = TIME + 1.
   GO TO 1060.
1410 IF (POINT1 - STORX) 1415, 1411, 1420
1411 XNOHA = 9
1412 POINT1 = STORX
   GO TO 1060.
1413 JHOL = 1
1414 GO TO 1425.
1415 IF (STORX - STORX(1+1)) 1285, 1290, 1420
1420 EXTIM(K) = TIME - 1.
   EXTIM(K+1) = POINT1
   IF (KEQ = 1) GO TO 1430.
1425 IF (EXTIM(K) > EXTIM(K-1)) GO TO 1430.
   GO TO 1430.
1430 K = K + 2
   ITEMS = ITEMS + 2
   GO TO 1425.
1500 CONTINUE
   JAY = ITEMS / 2
   J = J
   DO 1650 K = 1, ITEMS, 2
   JHR = EXTIM(K)
   JHT = MOD(JHR, 240)
   XJTIM(J) = MOD(JHR, 100) + JHT * 6
   XHT(J) = EXTIM(K+1)
   XHT(J+1) = EXTIM(K+1)
   XHT(J+2) = EXTIM(K+1)
   XHT(J+3) = EXTIM(K+1)
   XHT(J+4) = EXTIM(K+1)
   XHT(J+5) = EXTIM(K+1)
1600 IF (XHT(J) > EXTIM(K+1)) GO TO 1650.
1650 CONTINUE
   NDAY = NBAY(13)
   NCOUNT = 0
1670 NNJ = 1
1674 WRITE (6, 550)
   WRITE (6, 550) IYT, NDAY(13), DATUM, NOCONV, KSUM
   WRITE (6, 575)
   WRITE (6, 590)
1700 DO 1750 I = 1, JAY
1705 NCOUNT = NCOUNT + 1
1710 GO TO 1750.
1715 NLAST = NNJ + NCOUNT
1717 WRITE (6, 585)
   WRITE (6, 595)
   WRITE (6, 585)
   WRITE (6, 585)
   WRITE (6, 585)
   WRITE (6, 585)
   WRITE (6, 585)
1740 NNJ = NLAST + 1
   NCOUNT = 0
1745 IF (NBAY + 1) > NNEHA) GO TO 2000.
1750 CONTINUE
2000 CONTINUE
2005 READ (5, 638) MS, MY, MD
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.