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A FORTRAN FOR SOLVING SYSTEMS OF COUPLED SECOND-ORDER DIFFERENT--ETC(U)
AUG 76 J M FORBES, H B GARRETT F19628-76-C-0059
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A FORTRAN PROGRAM FOR SOLVING SYSTEMS OF COUPLED SECOND-ORDER DIFFERENTIAL EQUATIONS WITH TWO-POINT BOUNDARY CONDITIONS

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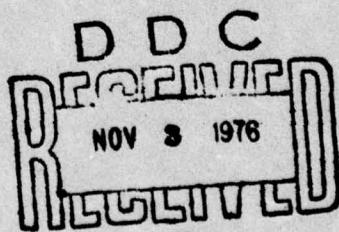
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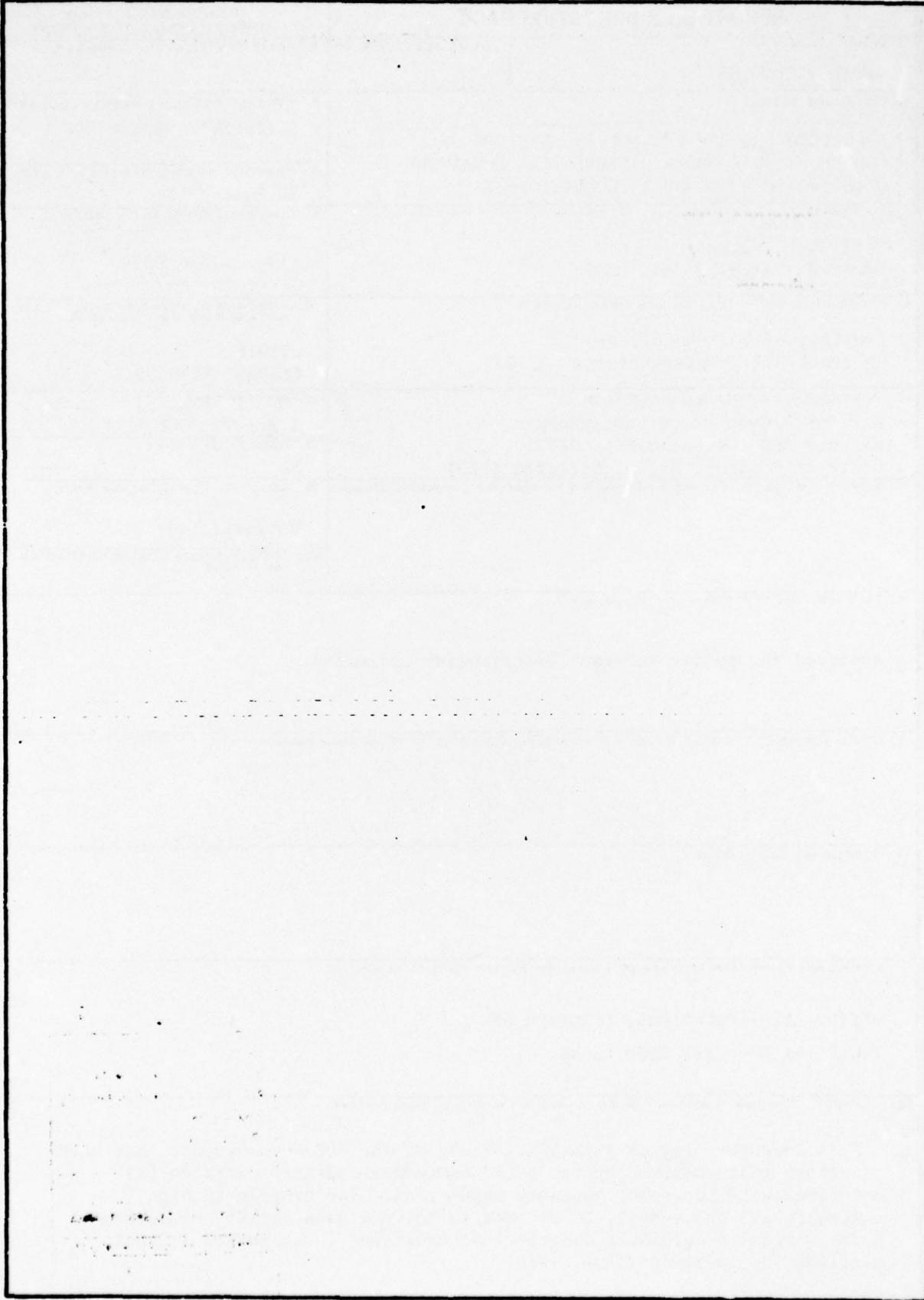
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A FORTRAN PROGRAM FOR SOLVING SYSTEMS OF COUPLED
SECOND-ORDER DIFFERENTIAL EQUATIONS WITH TWO-POINT
BOUNDARY CONDITIONS

INTRODUCTION

Systems of second-order ordinary differential equations with two-point boundary conditions are invariably encountered in problems of applied physics. Lindzen and Kuo (1969) have published an algorithm for solving such systems by the method of Gaussian Elimination. The method was found to be of particular value in the solution of various thermospheric tidal problems currently under investigation at Boston College and the Air Force Geophysics Laboratory. The following is a description of a computer program developed for the CDC 6600 computer which uses this technique. With the addition of a suitable user-supplied subroutine, the program can solve a wide variety of second-order ordinary and partial differential equations.

METHOD OF SOLUTION

A system of N coupled, second-order ordinary differential equations can be written in the following form:

$$\bar{C}'(x) \frac{d^2}{dx^2} \bar{F}(x) + \bar{A}'(x) \frac{d}{dx} \bar{F}(x) + \bar{B}'(x) \bar{F}(x) = \bar{R}'(x)$$

Where \bar{A}' , \bar{B}' , and \bar{C}' are NxN matrices and \bar{F} and \bar{R}' are N-dimensional vectors. To solve this system of equations numerically, we first change to finite differences. Letting $x_n = n\delta x$ ($n=1, 2, \dots$):

$$\frac{d}{dx} F(x_n) \approx \frac{F_{n+1} - F_{n-1}}{2 \delta x}$$

and

$$\frac{d^2}{dx^2} F(x_n) \approx \frac{F_{n+1} - 2F_n + F_{n-1}}{\delta x^2}$$

the new finite difference equations become:

$$1) \quad \bar{A}_n \bar{F}_{n-1} + \bar{B}_n \bar{F}_n + \bar{C}_n \bar{F}_{n+1} = \bar{R}_n$$

where

$$\bar{A}_n = \frac{\bar{C}'(x_n)}{(\delta x)^2} - \frac{\bar{A}'(x_n)}{2 \delta x}$$

$$\bar{B}_n = \frac{-2 \bar{C}'(x_n)}{(\delta x)^2} + \bar{B}'(x_n)$$

$$\bar{C}_n = \frac{\bar{C}'(x_n)}{(\delta x)^2} + \frac{\bar{A}'(x_n)}{2 \delta x}$$

$$\bar{R}_n = \bar{R}'(x_n)$$

Boundary conditions at x_1 and x_N are assumed to be of the form:

$$2) \quad \bar{C}'(x_1) \frac{d}{dx} \bar{F}|_{x_1} + \bar{A}'(x_1) \bar{F}(x_1) = \bar{R}'(x_1)$$

$$3) \quad \bar{C}'(x_N) \frac{d}{dx} \bar{F}|_{x_N} + \bar{A}'(x_N) \bar{F}(x_N) = \bar{R}'(x_N)$$

where x_1 is the value of x at the lower boundary and x_N is the value at the upper boundary. In finite difference form, these are:

$$4) \bar{\bar{A}}_1 \bar{F}_1 + \bar{\bar{B}}_1 \bar{F}_2 = \bar{R}_1$$

$$5) \bar{\bar{A}}_N \bar{F}_{N-1} + \bar{\bar{B}}_N \bar{F}_N = \bar{R}_N$$

$$\bar{\bar{A}}_1 = \bar{A}'(x_1) - \frac{\bar{\bar{C}}'(x_1)}{\delta x}$$

$$\bar{\bar{A}}_N = \frac{-\bar{\bar{C}}'(x_N)}{\delta x}$$

$$\bar{\bar{B}}_1 = \frac{\bar{\bar{C}}'(x_1)}{\delta x}$$

$$\bar{\bar{B}}_N = \frac{\bar{\bar{C}}'(x_N)}{\delta x} + A'(x_N)$$

$$\bar{R}_1 = \bar{R}'(x_1)$$

$$\bar{R}_N = \bar{R}'(x_N)$$

The solution (Richtmyer, 1957) is as follows. Assume:

$$6) \bar{F}_n = \bar{\bar{\alpha}}_n \bar{F}_{n+1} + \bar{\beta}_n$$

where $\bar{\bar{\alpha}}_n$ and $\bar{\beta}_n$ are to be determined. Then:

$$7) F_{n-1} = \bar{\bar{\alpha}}_{n-1} \bar{F}_n + \bar{\beta}_{n-1}$$

Equation 7, when substituted into 1, yields:

$$(\bar{\bar{A}}_n \bar{\bar{\alpha}}_{n-1} + \bar{\bar{B}}_n) \bar{F}_n + (\bar{\bar{C}}_n) \bar{F}_{n+1} = (\bar{R}_n - \bar{\bar{A}}_n \bar{\beta}_{n-1})$$

Comparing to Equation 6 yields:

$$8) \bar{\bar{\alpha}}_n = -(\bar{\bar{A}}_n \bar{\bar{\alpha}}_{n-1} + \bar{\bar{B}}_n)^{-1} \bar{\bar{C}}_n$$

$$9) \bar{\beta}_n = (\bar{\bar{A}}_n \bar{\bar{\alpha}}_{n-1} + \bar{\bar{B}}_n)^{-1} (\bar{R}_n - \bar{\bar{A}}_n \bar{\beta}_{n-1})$$

At the lower boundary, using Equation 6:

$$\bar{F}_1 = \bar{\bar{\alpha}}_1 \bar{F}_2 + \bar{\beta}_1$$

Therefore:

$$10) \bar{\alpha}_1 = -(\bar{A}_1)^{-1} \bar{B}_1$$

$$11) \bar{B}_1 = (\bar{A}_1)^{-1} R_1$$

Likewise, Equations 5 and 7 can be solved to give:

$$12) F_N = (\bar{A}_N \bar{\alpha}_{N-1} + \bar{B}_N)^{-1} (R_N - \bar{A}_N \bar{B}_{N-1})$$

We now have the means of solving the equations.

To review, we first calculate the finite difference form of the equations. $\bar{\alpha}_1$ and \bar{B}_1 are computed. Then we generate the other $\bar{\alpha}_n$ and \bar{B}_n , using Equations 8 and 9, through $\bar{\alpha}_N$ and \bar{B}_N (note: $\bar{\alpha}_N$ is not needed and $\bar{F}_N = \bar{B}_N$). The α and β , with Equation 6, generate the F_n , completing the solution.

PROGRAM

The computer formulation is straightforward (see Appendix I for listing). The main program, TIDE, calls subroutines ABCR, ABCRN, ALPBET, and SOL which perform the steps outlined in the previous description.

Subroutine ABCR is to be supplied by the user. This program calculates matrices \bar{A}' , \bar{B}' , and \bar{C}' and vector \bar{R}' for a given value of x . By proper manipulation of this subroutine, a variety of ordinary and partial differential equations can be solved.

Subroutine ABCRN calculates the matrices \bar{A}_n , \bar{B}_n , and \bar{C}_n and vector \bar{R}_n in the finite difference forms given in Equations 1, 4, and 5. Note that the matrices A, B, and C and vector R are reused. As the typical dimensions of such matrices are 40 x 40 or greater for our applications, this is a necessary process.

Subroutine ALPBET calculates $\bar{\alpha}_n$ and $\bar{\beta}_n$ from Equations 8, 9, 10, and 11. They are stored on TAPE 4. TAPE 3 is necessary as a work tape for otherwise twice as many matrices would be required. If the matrix dimensions permit, this tape could be deleted and replaced by storage matrices, with substantial savings in computer time.

Subroutine SOL uses Equation 7 to obtain the final solutions which appear in FNC. The output, in FNC, is printed, but it could be stored on a tape, plotted, or punched.

EXAMPLE

Appendices II and III contain the results of a sample calculation for 3 ordinary, second-order differential equations. Appendix II is the exact solution while Appendix III contains the numerical solution.

The example was defined as follows:

$$\bar{A}'(x) = \begin{vmatrix} 0 & 0 & ix^3 \\ 0 & x^2 & 0 \\ 0 & 0 & x^2 \end{vmatrix} \quad \bar{B}'(x) = \begin{vmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & x^2 \end{vmatrix}$$

$$\bar{C}'(x) = \begin{vmatrix} 2 & 0 & 0 \\ ix^3 & x^2 & 0 \\ 0 & 0 & 0 \end{vmatrix} \quad \bar{R}'(x) = \begin{cases} (4-3x^3) + i(4x^6) \\ i(8x^3 + 3x^4) \\ (4x^5 + x^6) + (3x^2 + 3x^3)i \end{cases}$$

$$i = \sqrt{-1}$$

The boundary conditions are, for $x = 0$ and $x = T$:

$$\bar{\bar{A}}'(0) = \begin{vmatrix} 0 & 0 & 0 \\ 0 & 0 & 2 \\ 0 & 3 & 0 \end{vmatrix} \quad \bar{\bar{B}}'(0) = 0$$

$$\bar{\bar{C}}'(0) = \begin{vmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{vmatrix} \quad \bar{\bar{R}}'(0) = \begin{vmatrix} 0 \\ 3i \\ 0 \end{vmatrix}$$

For $x = T$:

$$\bar{\bar{A}}'(T) = \begin{vmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & T^2 & 0 \end{vmatrix} \quad \bar{\bar{B}}'(T) = 0$$

$$\bar{\bar{C}}'(T) = \begin{vmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 2 & 0 \end{vmatrix} \quad \bar{\bar{R}}'(T) = \begin{vmatrix} T^2 \\ T^4 + 3T^i \\ i(6T^2 + T^5) \end{vmatrix}$$

The solutions to this system of equations are:

$$\bar{\bar{F}}(x) = \begin{vmatrix} x^2 \\ ix^3 \\ x^4 + (3x)i \end{vmatrix}$$

REFERENCES

Lindzen, R.S., and H.L. Kuo, "A Numerical Method for the Numerical
Integration of a Large Class of Ordinary and Partial Differential
Equations", Monthly Weather Review, Vol. 97, No. 10, 732-734, 1969.

Richtmyer, R.D., Difference Methods for Initial-Value Problems, Interscience
Press, New York, 1957.

APPENDIX I

C MAIN PROGRAM TIDE

C PURPOSE

C NUMERICALLY INTEGRATES EQUATION C(D²/DX²)F+A(D/DX)F+BF=R.
C WHERE A,B,C ARE MATRICES AND F,R ARE VECTORS. A,B,C,R
C ARE GIVEN BY SUBROUTINE ABCR. F IS TO BE COMPUTED

C USAGE

C PROVIDE INPUT SUBROUTINE ABCR. OUTPUT AT STATEMENTS 10
C AND 11.

C DESCRIPTION OF PARAMETERS

C A - INPUT MATRIX
C B - INPUT MATRIX
C C - INPUT MATRIX
C R - INPUT VECTOR
C BET - STORAGE VECTOR
C FNC1 - STORAGE VECTOR
C FNC - OUTPUT VECTOR
C DETERM - DETERMINANT VALUE FROM MATRIX INVERSION. ILL-
C CONDITIONED PROBLEM WILL GIVE 0.
C IR - NUMBER OF ROWS
C IC - NUMBER OF COLUMNS
C S1 - INITIAL VALUE OF X
C SN - FINAL VALUE OF X
C N - NUMBER OF STEPS

C REMARKS

C USER SHOULD CHANGE DIMENSIONS AS APPROPRIATE. IN THIS
C CASE WHERE THE NUMBER 3 APPEARS. OUTPUT IS AT STATEMENTS
C 10 AND 11.

C SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED

C ABCR - SETS UP PROBLEM
C ADORN - CONVERTS USER'S PROBLEM TO FINITE DIFFERENCE FORM.
C ALPBET - COMPUTES INTERMEDIATE SOLUTIONS ALPHA AND BETA
C CABS - SYSTEM FUNCTION
C SOL - COMPUTES FINAL SOLUTIONS F(X)

C METHOD

C SEE LINDZEN AND KUO, MONTHLY WEATHER REVIEW, VOL. 97, NO.
C 10, OCT 1969, 732-734.

C PROGRAM TIDE(INPUT,OUTPUT,TAPE3=513,TAPE4)

C CHANGE DIMENSTONS

C COMPLEX A(3,3),B(3,3),C(3,3),R(3)
C COMPLEX BET(3),FNC(3),FNC1(3),DETERM
C IR=3
C IC=3

C INTEGRATE FROM:

C S1=0

```

C      10:
C
C      SN=2
C
C      IN STEPS OF:
C
C      DX=.01
C
C      NUMBER OF STEPS WILL BE:
C
C      N=(SN-S1)/DX+1.001
100 FORMAT(5(1X, E13.6))
      DO 7 I=1,N
      X=DX*FLOAT(I-1)+S1
C
C      SET UP MATRICES
C
C      CALL ABCR(A,B,C,R,I,N,X,IR,IC)
C
C      COMPUTE MATRICES A,B,C AND VECTOR R IN FINITE DIFFERENCE FORM
C
C      CALL ABCRN(A,B,C,I,N,IR,IC,DX)
C
C      COMPUTE ALPHA AND BETA MATRICES
C
C      CALL ALPBET(A,B,C,R,BET,FNC1,L,N,IR,IC,DETERM)
      LET=UABS(DETERM)
      IF(DFT) 7,99,7
7 CONTINUE
      DO 4 I=1,IR
      FNC(I)=BET(I)
4 FNC1(I)=BET(I)
10 PRINT 100,FNC
      DO 5 I=2,N
      BACKSPACE 4
      BACKSPACE 4
      READ(4) A,BET
C
C      COMPUTE FUNCTION
C
C      CALL SOL(A,BET,FNC,FNC1,IR,IC)
11 PRINT 100,FNC
      DO 6 J=1,IR
5 FNC1(J)=FNC(J)
      GO TO 97
39 PRINT 100,DETERM
97 CONTINUE
      STOP
      END

```

C SUBROUTINE ABCR

C PURPOSE

C USER-PROVIDED SUBROUTINE THAT SETS UP EQUATIONS TO BE
C SOLVED. LOWER BOUNDARY CONDITIONS ARE GIVEN IN STATEMENT 10
C TO 11, UPPER BOUNDARY CONDITIONS IN 4 TO 12, AND EQUATIONS
C IN 3 TO 6.

C USAGE

C SET UP MATRICES A,B,C AND VECTOR R.

C DESCRIPTION OF PARAMETERS

C A1 - OUTPUT MATRIX
C B1 - OUTPUT MATRIX
C C1 - OUTPUT MATRIX
C R1 - OUTPUT VECTOR

C REMARKS

C USER-PROVIDED. THE SOLUTION TO THIS EXAMPLE IS:
C $F(X) = (X^{**2}, I^*(X^{**3}), X^{**4} + 3*X*I)$

C SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED

C NONE

C METHOD

C USER SUPPLIED

C.....
C SUBROUTINE ABCR(A1,B1,C1,R1,K,N,X,IR,IC)

C CHANGE DIMENSIONS

C COMPLEX A1(3,3),B1(3,3),C1(3,3),R1(3)
C 0 1 I=1,IR
C 0 1 J=1,IC
1 A1(I,J)=B1(I,J)=C1(I,J)=CMPLX(0.0,0.0)
10 IF(K-1) 2,2,3
2 C1(1,1)=C1(2,3)=CMPLX(1.,0.0)
A1(2,3)=CMPLX(2.,0.0)
A1(3,2)=CMPLX(3.,0.0)
R1(1)=R1(3)=CMPLX(0.0,0.0)
11 R1(2)=CMPLX(0.0,3.0)
GO TO 6
3 IF(K-N) 5,4,4
4 A1(1,1)=CMPLX(1.,0.0)
L1(3,2)=CMPLX(2.,0.0)
A1(2,3)=CMPLX(1.,0.0)
A=X*X
A1(3,2)=CMPLX(A,0.0)
E=A*A
BI=3.*X
(I=C.*X*X+A*A*X
F1(1)=CMPLX(A,0.0)
R1(2)=CMPLX(B,BI)
12 F1(3)=CMPLX(0.0,C1)
GO TO 6

```
S (1(1,1)=CMPLX(2.0,J.0)
T1=X*X
T2=X*T1
T3=T2*X
T4=T3*X
T5=T4*X
C1(2,1)=A1(1,3)=CMPLX(0.0,T2)
C1(2,2)=A1(2,2)=A1(3,3)=B1(3,3)=CMPLX(T1,0.0)
F=4.-3.*T2
FI=4.*T5
F1(1)=CMPLX(R,RI)
KI=0.*T2+3.*T3
F1(2)=CMPLX(0.0,RI)
F=4.*T4+T5
FI=3.*T1+3.*T2
K1(3)=CMPLX(R,RI)
E CONTINUE
RETURN
END
```

SUBROUTINE ABCRN

PURPOSE

CONVERTS DIFFERENTIAL FORM OF EQUATIONS TO FINITE DIFFERENCE FORM.

USAGE

INPUT MATRICES A,B,C AND X VALUE. OUTPUT IN A,B,C.

DESCRIPTION OF PARAMETERS

A - INPUT,OUTPUT MATRIX
B - INPUT,OUTPUT MATRIX
K - STEP NUMBER
N - FINAL STEP NUMBER
IR - NUMBER OF ROWS
IC - NUMBER OF COLUMNS
DX - STEP SIZE

REMARKS

DIMENSIONS MUST BE CHANGED

SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED

NONE

METHOD

FINITE DIFFERENCE APPROXIMATION TO DIFFERENTIAL.

SUBROUTINE ABCRN(A,B,C,K,N,IR,IC,DX)

CHANGE DIMENSIONS

COMPLEX A(3,3),B(3,3),C(3,3)

F=1./DX

10 IF(K-1) 1,1,2

20 IF(K-N) 3,8,8

10 DO 10 I=1,IR

10 DO 10 J=1,IC

A(I,J)=A(I,J)-F*C(I,J)

10 E(I,J)=F*C(I,J)

10 DO 10 6

30 F2=F+F

30 F3=F/2.

30 F4=-2.*F2

30 DO 20 I=1,IR

30 DO 20 J=1,IC

E(I,J)=3(I,J)+F4*C(I,J)

C(I,J)=F2*C(I,J)+F3*A(I,J)

20 F(I,J)=C(I,J)-F*A(I,J)

20 DO 20 6

30 DO 30 I=1,IR

30 DO 30 J=1,IC

B(I,J)=A(I,J)+F*C(I,J)

30 A(I,J)=-F*C(I,J)

30 RETURN

END

C SUBROUTINE ALPBET

C PURPOSE

C CALCULATES ALPHA AND BETA WHICH ARE NEEDED AS INTERMEDIATE
C SOLUTIONS. OUTPUT APPEARS ON TAPE4.

C USAGE

C PROVIDE INPUT MATRICES A,B,C AND VECTOR D. RETURN ALPHA
C AND BETA ON TAPE4.

C DESCRIPTION OF PARAMETERS

C A - INPUT MATRIX
C B - INPUT MATRIX
C C - INPUT MATRIX
C D - INPUT VECTOR
C BET - WORKING VECTOR
C FNC1 - WORKING VECTOR
C K - STEP NUMBER
C N - FINAL STEP NUMBER
C IR - NUMBER OF ROWS
C IC - NUMBER COLUMNS
C DETERM - VALUE OF DETERMINANT

C REMARKS

C TAPE3 IS A WORK TAPE. IN MANY CASES IT CAN BE REPLACED
C WITH MATRICES TO CUT RUN TIME

C SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED

C MINV - MATRIX INVERSION
C MPRDD - MATRIX MULTIPLICATION
C GMADD - MATRIX ADDITION

C METHOD

C SEE REFERENCE

C.....
C SUBROUTINE ALPBET(A,B,C,D,BET,FNC1,K,N,IR,IC,DETERM)

C CHANGE DIMENSIONS

100 COMPLEX A(3,3),B(3,3),C(3,3),D(3),BET(3),FNC1(3),DETERM
101 FORMAT(6(1X,E13.6))
101 FORMAT(1X,I+)
1 IF(K-1) 1,1,2
1 CALL MINV(A,IC,D,1,DETERM)
1 DO 11 KI=1,IR
1 DO 11 JI=1,IC
11 A(KI,JI)=-A(KI,JI)
1 CALL MPRDD(A,B,C,IR,IC,IC)
C
C WRITE(3) 0,0
C WRITE(4) 0,0
C RETURN

```

2      CONTINUE
C
C      STORE CN AND BN ON TAPES
C
C      WRITE(3) C,B
C      REWIND 3
C
C      READ AL(N-1) AND BET(N-1) FROM TAPE3
C
C      READ(3) C,BET
C
C      CALL MPROD(A,BET,FNC1,IR,IC,1)
C      CALL GMADD(B,FNC1,BET,IR,1,-1.)
C      CALL MPROD(A,C,B,IR,IC,IC)
C      DO 4 I=1,IR
C      DO 4 J=1,IC
C      A(I,J)=B(I,J)
4
C
C      RETRIEVE CN AND BN FROM TAPE3
C
C      READ(3) C,B
C      DO 5 I=1,IR
C      DO 5 J=1,IC
5      C(I,J)=-C(I,J)
C      REWIND 3
C
C      CALL GMADD(B,A,B,IR,IC,1.)
C      CALL MINV(B,IC,BET,1,DETERM)
C      CALL MPROD(B,C,A,IR,IC,IC)
C
C      WRITE BET(N) AND AL(N) ON TAPE3
C
C      WRITE(3) A,BET
C
C      WRITE BET(N) AND AL(N) ON TAPE4
C
C      WRITE(4) A,BET
C      RETURN
C      END

```

C SUBROUTINE SOL

C PURPOSE

GIVEN INTERMEDIATE SOLUTIONS ALPHA AND BETA AND PREVIOUS
C VALUE OF F(X), SOLVES FOR F(X-DX).

C USAGE

C PROVIDE ALPHA, BETA, AND F(X). RETURNS F(X-DX).

C DESCRIPTION OF PARAMETERS

C ALP - INPUT MATRIX ALPHA

C BET - INPUT VECTOR BETA

C FNC1 - PREVIOUS VECTOR SOLUTION F(X)

C FNC - RETURNED VECTOR SOLUTION F(X-DX)

C REMARKS

C NONE

C SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED

C GMADD - MATRIX ADDITION

C MPROD - MATRIX MULTIPLICATION

C METHOD

C SEE REFERENCE.

.....
C SUBROUTINE SOL(ALP,BET,FNC,FNC1,IR,IC)

C CHANGE DIMENSIONS

C COMPLEX ALP(3,3),BET(3),FNC(3),FNC1(3)
CALL MPROD(ALP,FNC1,FNC,IR,IC,1)
CALL GMADD(FNC,BET,FNC,IR,1,1.)
RETURN
END

C SUBROUTINE MINV

C PURPOSE

C MATRIX INVERSION WITH ACCOMPANING SOLUTIONS OF LINEAR
C EQUATIONS.

C USAGE

C INPUT MATRICES A AND B. RETURNS A-INVERSE IN A AND A-INVERSE
C TIMES B IN B.

C DESCRIPTION OF PARAMETERS

C A - INPUT MATRIX TO BE INVERTED
C INVERSE RETURNED IN A.
C B - MATRIX OR VECTOR SUCH THAT AX*B=B.
C A-INVERSE TIMES B RETURNED IN B.
C N - COLUMNS IN A, ROWS IN B.
C M - COLUMNS IN B.
C DETERM - DETERMINANT OF A

C REMARKS

C F1 NBSB MATINV MATRIX INVERSION

C SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED

C CABS - SYSTEM FUNCTION

C METHOD

C GAUSSIAN ELIMINATION WITH PARTIAL PIVOTING.

C.....
C SUBROUTINE MINV(A,N,B,M,DETERM)

C CHANGE DIMENSIONS

C DIMENSION A(3,3),B(3,1),PIVOT(3),IPIVOT(3),INDEX(3,2)
C COMPLEX A,B,DETERM,PIVOT,AMAX,SWAP,T

C INITIALIZATION

10 DETERM= CMPLX (1.0,0.0)
15 DO 20 J=1,N
20 IPIVOT(J)=0
30 DO 550 I=1,N

C SEARCH FOR PIVOT ELEMENT

40 AMAX= CMPLX (0.0,0.0)
45 DO 105 J=1,N
50 IF(IPIVOT(J)-1)60,105,60
60 DO 100 K=1,N
70 IF(IPIVOT(K)-1)30,100,740
80 IF(CABS(AMAX)-CABS(A(J,K)))35,100,100
85 IROW=J
90 ICOLUMN=K
95 AMAX=A(J,K)
100 CONTINUE
105 CONTINUE

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110  IPIVOT(ICOLUMN)=IPIVOT(ICOLUMN)+1
C
C      INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL
C
130  IF(IROW-ICOLUMN) 1+0,200,140
140  DETERM=-DETERM
150  DO 210 L=1,N
160  SWAP=A(IROW,L)
170  A(IROW,L)=A(ICOLUMN,L)
180  A(ICOLUMN,L)=SWAP
200  IF(M)260,260,210
210  DO 250 L=1,M
220  SWAP=B(IROW,L)
230  B(IROW,L)=B(ICOLUMN,L)
240  B(ICOLUMN,L)=SWAP
250  INDEX(I,1)=IROW
260  INDEX(I,2)=ICOLUMN
310  PIVOT(I)=A(ICOLUMN,ICOLUMN)
320  DETERM=DETERM*PIVOT(I)
330  DET=CABS(DETERM)
340  IF(DET    )330,740,330
C
C      DIVIDE PIVOT ROW BY PIVOT ELEMENT
C
330  A(ICOLUMN,ICOLUMN)= CMPLX(1.0,0.0)
340  DO 350 L=1,N
350  A(ICOLUMN,L)=A(ICOLUMN,L)/PIVOT(I)
355  IF(M)380,380,360
360  DO 370 L=1,M
370  B(ICOLUMN,L)=B(ICOLUMN,L)/PIVOT(I)
C
C      REDUCE NON-PIVOT ROWS
C
380  TO 550 L1=1,N
390  IF(L1-ICOLUMN)400,550,400
400  T=A(L1,ICOLUMN)
420  A(L1,ICOLUMN)= CMPLX(0.0,0.0)
430  DO 450 L=1,N
450  A(L1,L)=A(L1,L)-A(ICOLUMN,L)*T
455  IF(M)550,550,-60
460  DO 510 L=1,M
500  B(L1,L)=B(L1,L)-B(ICOLUMN,L)*T
550  CONTINUE
C
C      INTERCHANGE COLUMNS
C
580  LU 710 I=1,N
590  L=N+1-I
620  IF(INDEX(L,1)-INDEX(L,2))630,710,630
630  JROW=INDEX(L,1)
640  JCOLUMN=INDEX(L,2)
650  DO 705 K=1,N
660  SWAP=A(K,JROW)
670  A(K,JROW)=A(K,JCOLUMN)
680  A(K,JCOLUMN)=SWAP
695  CONTINUE
710  CONTINUE
740  RETURN
END

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C SUBROUTINE GMADD
C
C PURPOSE
C   ADD TWO GENERAL MATRICES TO FORM RESULTANT GENERAL MATRIX
C
C USAGE
C   CALL GMADD(A,B,R,N,M,AOS)
C
C DESCRIPTION OF PARAMETERS
C   A - NAME OF FIRST INPUT MATRIX
C   B - NAME OF SECOND INPUT MATRIX
C   R - NAME OF OUTPUT MATRIX
C   N - NUMBER OF ROWS IN A,B,R
C   M - NUMBER OF COLUMNS IN A,B,R
C
C REMARKS
C   ALL MATRICES MUST BE STORED AS GENERAL MATRICES
C
C SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
C   NONE
C
C METHOD
C   ADDITION IS PERFORMED ELEMENT BY ELEMENT
C
C .....  

C
C SUBROUTINE GMADD(A,B,R,N,M,AOS)
C COMPLEX A(1),B(1),R(1)
C
C   CALCULATE NUMBER OF ELEMENTS
C
C   NM=N*M
C
C   ADD MATRICES
C
C   10 10 I=1,NM
C       F(I)=A(I)+AOS*B(I)
C   RETURN
C   END

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C      SUBROUTINE MPROD
C
C      PURPOSE
C          MULTIPLY TWO GENERAL MATRICES TO FORM A RESULTANT GENERAL
C          MATRIX
C
C      USAGE
C          CALL MPROD(A,B,R,N,M,L)
C
C      DESCRIPTION OF PARAMETERS
C          A - NAME OF FIRST INPUT MATRIX
C          B - NAME OF SECOND INPUT MATRIX
C          R - NAME OF OUTPUT MATRIX
C          N - NUMBER OF ROWS IN A
C          M - NUMBER OF COLUMNS IN A AND ROWS IN B
C          L - NUMBER OF COLUMNS IN B
C
C      REMARKS
C          ALL MATRICES MUST BE STORED AS GENERAL MATRICES
C          MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX A
C          MATRIX R CANNOT BE IN THE SAME LOCATION AS MATRIX B
C          NUMBER OF COLUMNS OF MATRIX A MUST BE EQUAL TO NUMBER OF ROW
C          OF MATRIX B
C
C      SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
C
C          NONE
C
C      METHOD
C          THE M BY L MATRIX B IS PREMULTIPLIED BY THE N BY M MATRIX A
C          AND THE RESULT IS STORED IN THE N BY L MATRIX R.
C
C      ****
C
C      SUBROUTINE MPROD(A,B,R,N,M,L)
C      COMPLEX A(1),B(1),R(1)
C
C
C          IR=0
C          IK=-M
C          DO 10 K=1,L
C          IK=IK+M
C          DO 10 J=1,N
C          IR=IR+1
C          JI=J-N
C          IB=IK
C          F(IR)=(0.0,0.0)
C          DO 10 I=1,M
C          JI=JI+N
C          IB=IB+1
C 10    F(IR)=R(IR)+A(JI)*B(IB)
C          RETURN
C          END

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APPENDIX II

$X_5 - n_6 x = x$

x^3

x^2

$x^4 + 3x^1$

x^0	x^1	x^2	x^3	$x^4 + 3x^1$
$2.00000E+01$	$4.00000E+01$	$0.$	$0.$	$1.60000E+02$
$1.99000E+01$	$3.96110E+01$	$0.$	$0.$	$1.56024E+02$
$1.98000E+01$	$3.92040E+01$	$0.$	$0.$	$1.53632E+02$
$1.97000E+01$	$3.88030E+01$	$0.$	$0.$	$1.50614E+02$
$1.96000E+01$	$3.64160E+01$	$0.$	$0.$	$7.64537E+01$
$1.95000E+01$	$3.50220E+01$	$0.$	$0.$	$7.52954E+01$
$1.94000E+01$	$3.36360E+01$	$0.$	$0.$	$4.1427E+01$
$1.93000E+01$	$3.22490E+01$	$0.$	$0.$	$7.30138E+01$
$1.92000E+01$	$3.08520E+01$	$0.$	$0.$	$7.13306E+01$
$1.91000E+01$	$3.64010E+01$	$0.$	$0.$	$7.07739E+01$
$1.90000E+01$	$3.61030E+01$	$0.$	$0.$	$6.95737E+01$
$1.89000E+01$	$3.57210E+01$	$0.$	$0.$	$6.75127E+01$
$1.88000E+01$	$3.53440E+01$	$0.$	$0.$	$6.64467E+01$
$1.87000E+01$	$3.49630E+01$	$0.$	$0.$	$5.53920E+01$
$1.86000E+01$	$3.45530E+01$	$0.$	$0.$	$4.43436E+01$
$1.85000E+01$	$3.42250E+01$	$0.$	$0.$	$3.33152E+01$
$1.84000E+01$	$3.38550E+01$	$0.$	$0.$	$6.22350E+01$
$1.83000E+01$	$3.34890E+01$	$0.$	$0.$	$512849E+01$
$1.82000E+01$	$3.31249E+01$	$0.$	$0.$	$6.023357E+01$
$1.81000E+01$	$3.27610E+01$	$0.$	$0.$	$5.29297E+01$
$1.80000E+01$	$3.24000E+01$	$0.$	$0.$	$5.863200E+01$
$1.79000E+01$	$3.20410E+01$	$0.$	$0.$	$4.73534E+01$
$1.78000E+01$	$3.16805E+01$	$0.$	$0.$	$5.66397E+01$
$1.77000E+01$	$3.13230E+01$	$0.$	$0.$	$5.54425E+01$
$1.76000E+01$	$3.09756E+01$	$0.$	$0.$	$4.742173E+01$
$1.75000E+01$	$3.06250E+01$	$0.$	$0.$	$5.35937E+01$
$1.74000E+01$	$3.02760E+01$	$0.$	$0.$	$5.263025E+01$
$1.73000E+01$	$2.99290E+01$	$0.$	$0.$	$4.217772E+01$
$1.72000E+01$	$2.95840E+01$	$0.$	$0.$	$5.03845E+01$
$1.71000E+01$	$2.92410E+01$	$0.$	$0.$	$5.00021E+01$
$1.70000E+01$	$2.89276E+01$	$0.$	$0.$	$4.91301E+01$
$1.69000E+01$	$2.86610E+01$	$0.$	$0.$	$4.82561E+01$
$1.68000E+01$	$2.82240E+01$	$0.$	$0.$	$4.74153E+01$
$1.67000E+01$	$2.78690E+01$	$0.$	$0.$	$4.65749E+01$
$1.66000E+01$	$2.75560E+01$	$0.$	$0.$	$4.57430E+01$
$1.65000E+01$	$2.72250E+01$	$0.$	$0.$	$4.49212E+01$
$1.64000E+01$	$2.68930E+01$	$0.$	$0.$	$4.41094E+01$
$1.63000E+01$	$2.65630E+01$	$0.$	$0.$	$4.33075E+01$
$1.62000E+01$	$2.5240E+01$	$0.$	$0.$	$4.26153E+01$
$1.61000E+01$	$2.52210E+01$	$0.$	$0.$	$4.17328E+01$
$1.60000E+01$	$2.56030E+01$	$0.$	$0.$	$4.03601E+01$
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• 500000E+00	• 1345000E+00	• 2116000E+00	• 2116000E+00
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• 450000E+00	• 3556000E+00	• 1662000E+00	• 1662000E+00
• 440000E+00	• 1578000E+00	• 1600000E+00	• 1600000E+00
• 430000E+00	• 1380000E+00	• 1521000E+00	• 1521000E+00
• 420000E+00	• 1182000E+00	• 1444000E+00	• 1444000E+00
• 410000E+00	• 9842000E+00	• 1363000E+00	• 1363000E+00
• 400000E+00	• 7864000E+00	• 1296000E+00	• 1296000E+00
• 390000E+00	• 5886000E+00	• 1122100E+00	• 1122100E+00
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• 325509E+00	• 213614F+00	• 204000F+01	• 204000F+01
• 314+32E+00	• 201511E+00	• 201000L+01	• 201000L+01
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• 287436E+00	• 178505E+00	• 195000E+01	• 195000E+01
• 277025E+00	• 167772E+00	• 192000E+01	• 192000E+01
• 262144E+00	• 157530E+00	• 189000E+01	• 189000E+01
• 250047E+00	• 147763E+00	• 166000E+01	• 166000E+01
• 236329E+00	• 136458E+00	• 163000E+01	• 163000E+01
• 226381E+00	• 129600E+00	• 160000E+01	• 160000E+01
• 216000E+00	• 121174E+00	• 177000E+01	• 177000E+01
• 205379E+00	• 113165E+00	• 174000E+01	• 174000E+01
• 195112E+00	• 105560E+00	• 171000E+01	• 171000E+01
• 185193E+00	• 983450E-01	• 166000E+01	• 166000E+01
• 17616E+00	• 915052E-01	• 165000E+01	• 165000E+01
• 166375E+00	• 820305F-01	• 162000E+01	• 162000E+01
• 15745F+00	• 789048E-01	• 159000E+01	• 159000E+01
• 146837E+00	• 731162E-01	• 156000E+01	• 156000E+01
• 140509E+00	• 676520E-01	• 153000E+01	• 153000E+01
• 132651E+00	• 625000E-01	• 150000E+01	• 150000E+01
• 125000E+00	• 576498F-01	• 147000F+01	• 147000F+01
• 1176+9E+00	• 530842E-01	• 144000E+01	• 144000E+01
• 110592E+00	• 487568E-01	• 141000E+01	• 141000E+01
• 103323E+00	• 447749F-01	• 138000E+01	• 138000E+01
• 373350E-01	• 4100525-01	• 135000E+01	• 135000E+01
• 911250E-01	• 351849E-01	• 3748105-01	• 132000E+01
• 95070E-01	• 3+1e895-01	• 129000E+01	• 129000E+01
• 740330E-01	• 3111705-01	• 126000E+01	• 126000E+01
• 6892105-01	• 282576E-01	• 123000E+01	• 123000E+01
• 640000E-01	• 256090E-01	• 120000E+01	• 120000E+01
• 593190E-01	• 231344E-01	• 117000E+01	• 117000E+01
• 548720E-01	• 208514F-01	• 114000E+01	• 114000E+01
• 506530E-01	• 187416E-01	• 111000E+01	• 111000E+01
• 466556E-01	• 167952E-01	• 108000E+01	• 108000E+01
• 593190E-01	• 1505627-01	• 105000F+01	• 105000F+01
• 548720E-01	• 133634E-01	• 102000E+01	• 102000E+01
• 506530E-01	• 1155325-01	• 99000E+00	• 99000E+00

• 320000E+00	• 102-J0E+00	0.
• 310000E+00	• 961000E-01	0.
• 300000E+00	• 900000E-01	0.
• 290000E+00	• 840000E-01	0.
• 280000E+00	• 784000E-01	0.
• 270000E+00	• 729000E-01	0.
• 260000E+00	• 676000E-01	0.
• 250000E+00	• 625000E-01	0.
• 240000E+00	• 576000E-01	0.
• 230000E+00	• 529000E-01	0.
• 220000E+00	• 484000E-01	0.
• 210000E+00	• 440000E-01	0.
• 200000E+00	• 400000E-01	0.
• 190000E+00	• 351000E-01	0.
• 180000E+00	• 324000E-01	0.
• 170000E+00	• 295000E-01	0.
• 160000E+00	• 258000E-01	0.
• 150000E+00	• 225000E-01	0.
• 140000E+00	• 196000E-01	0.
• 130000E+00	• 169000E-01	0.
• 120000E+00	• 144000E-01	0.
• 110000E+00	• 121000E-01	0.
• 100000E+00	• 100000E-01	0.
• 900000E-01	• 810000E-02	0.
• 800000E-01	• 640000E-02	0.
• 700000E-01	• 490000E-02	0.
• 600000E-01	• 360000E-02	0.
• 500000E-01	• 220000E-02	0.
• 400000E-01	• 150000E-02	0.
• 300000E-01	• 900000E-03	0.
• 200000E-01	• 400000E-03	0.
• 100000E-01	• 100000E-03	0.

APPENDIX III

2

1x³x⁴+3xi

• 40000C0F+01	• 475E093E-05	• 04748E-03	• 6274E-03	• 160000E+12	• 500000E+01
• 396C20F+01	-• 6506E-05	-• 106129E-03	-• 795835E+01	-• 156322E+12	-• 597000E+01
• 392060F+01	-• 144264E-04	-• 113643E-03	-• 770105E+01	-• 153695E+02	-• 594000E+01
• 388120F+01	-• 107226E-04	-• 11359E-03	-• 767304E+01	-• 153612E+12	-• 591000E+01
• 38420CE+01	-• 107226E-04	-• 755716E+01	-• 147573E+12	-• 592000E+01	-• 591000E+01
• 38030CE+01	-• 242106F-04	-• 115482E-03	-• 744245E+01	-• 144589E+12	-• 585000E+01
• 376420E+01	-• 291544F-04	-• 113042E-03	-• 732692E+01	-• 141647E+12	-• 582000E+01
• 372560F+01	-• 340957E-04	-• 120632F-03	-• 721654E+01	-• 138747E+12	-• 579000F+01
• 368720E+01	-• 395672E-04	-• 123285E-03	-• 710533E+01	-• 135996E+12	-• 576000E+01
• 364900E+01	-• 440342E-04	-• 125961E-03	-• 699527E+01	-• 133085E+12	-• 573000E+01
• 361100E+01	-• 495382E-04	-• 123746E-03	-• 605635E+01	-• 130322E+12	-• 570000E+01
• 357320F+01	-• 540237E-04	-• 131519E-03	-• 677857E+01	-• 127598E+12	-• 567000E+01
• 353560F+01	-• 904545E-04	-• 134888E-03	-• 667192E+01	-• 124921E+12	-• 564000E+01
• 349820E+01	-• 644205E-04	-• 137236E-03	-• 656645E+01	-• 122228E+12	-• 561000E+01
• 346100E+01	-• 699692E-04	-• 140173E-03	-• 646201E+01	-• 119689E+12	-• 550000E+01
• 342400E+01	-• 74655E-04	-• 143035E-03	-• 635873E+01	-• 117134E+12	-• 550000E+01
• 338720F+01	-• 701868E-04	-• 146667E-03	-• 625655E+01	-• 114624E+12	-• 552000E+01
• 335060E+01	-• 840761F-04	-• 140622E-03	-• 615549E+01	-• 112151E+12	-• 549000E+01
• 331420E+01	-• 997825E-04	-• 152035E-03	-• 615552E+01	-• 109721E+12	-• 546000CF+01
• 327800F+01	-• 940547E-04	-• 155922E-03	-• 555664E+01	-• 107323E+12	-• 543000E+01
• 324200E+01	-• 991396E-04	-• 153056E-03	-• 595895E+01	-• 104977E+12	-• 540000E+01
• 329620E+01	-• 1027945E-04	-• 151154E-03	-• 576213E+01	-• 102662E+12	-• 537000E+01
• 317060F+01	-• 1084978E-04	-• 164543E-03	-• 566644E+01	-• 1003295E+12	-• 534000E+01
• 313520F+01	-• 113850E-03	-• 1670915-03	-• 557192E+01	-• 981506E+01	-• 531000E+01
• 310000E+01	-• 111764E-03	-• 173122E-03	-• 547841E+01	-• 953528E+01	-• 528000E+01
• 306500F+01	-• 123536E-03	-• 173157E-03	-• 538595E+01	-• 937892E+11	-• 525000E+01
• 303020F+01	-• 120514E-03	-• 17649E-03	-• 524558E+01	-• 16653E+11	-• 522000E+01
• 299560E+01	-• 123328E-03	-• 179080E-03	-• 520419E+01	-• 95737E+01	-• 519000E+01
• 296120E+01	-• 13142E-03	-• 18205E-03	-• 51166E+01	-• 975232E+01	-• 516000E+01
• 292709E+01	-• 123536E-03	-• 173157E-03	-• 538595E+01	-• 937892E+11	-• 513000E+01
• 289300F+01	-• 147565E-02	-• 17649E-03	-• 524558E+01	-• 16653E+11	-• 510000E+01
• 285920E+01	-• 152377E-02	-• 195624E-02	-• 465305E+01	-• 95737E+01	-• 507000F+01
• 282560E+01	-• 157370E-02	-• 193670E-03	-• 476761E+01	-• 766616E+01	-• 504000E+01
• 279220F+01	-• 161712E-02	-• 196518E-03	-• 524558E+01	-• 777834E+01	-• 501000E+01
• 275900E+01	-• 16535E-02	-• 199742E-03	-• 493629E+01	-• 759356E+01	-• 498000E+01
• 272600F+01	-• 17305E-02	-• 202107E-03	-• 451642E+01	-• 74214E+01	-• 495000E+01
• 269320F+01	-• 175453E-02	-• 204864E-03	-• 476689E+01	-• 723419E+01	-• 492000E+01
• 266000F+01	-• 173046E-02	-• 207564E-03	-• 485662E+01	-• 705923E+01	-• 489000E+01
• 262820E+01	-• 186415E-02	-• 21239E-03	-• 427734E+01	-• 688774E+01	-• 486000E+01
• 259600E+01	-• 198920E-02	-• 21266E-03	-• 419903E+01	-• 671912E+01	-• 483000E+01
• 256400E+01	-• 21135E-02	-• 214545E-03	-• 412468E+01	-• 553895E+01	-• 480000E+01
• 253220E+01	-• 207541E-02	-• 21716E-03	-• 414553E+01	-• 534144E+01	-• 477000E+01

• 250060E+01	-• 201838E-03	-• 2220495E-03	• 396986E+01	• 623230E+01
• 266920E+01	-• 206078E-03	-• 222937E-03	• 389539E+01	• 607590E+01
• 243800E+01	-• 210285E-03	-• 225352E-03	• 392164E+01	• 592272E+01
• 240700E+01	-• 214433E-03	-• 227699E-03	• 374923E+01	• 577220E+01
• 237620E+01	-• 218545E-03	-• 230014E-03	• 367755E+01	• 562481E+01
• 234560E+01	-• 222598E-03	-• 232261E-03	• 366679E+01	• 549002E+01
• 231520E+01	-• 226614E-03	-• 234473E-03	• 353695E+01	• 533829E+01
• 229500E+01	-• 230570E-03	-• 236616E-03	• 346803E+01	• 519908E+01
• 225500E+01	-• 234466E-03	-• 238721E-03	• 340001E+01	• 506286E+01
• 222520E+01	-• 238343F-03	-• 240755E-03	• 333288E+01	• 492909E+01
• 219560E+01	-• 242158F-03	-• 242749E-03	• 326665E+01	• 479823E+01
• 216620E+01	-• 245313E-03	-• 244673E-03	• 320131E+01	• 466976E+01
• 213700E+01	-• 249625E-03	-• 246553E-03	• 313685E+01	• 454411E+01
• 210800F+01	-• 253276E-03	-• 248363F-03	• 307326E+01	• 442079E+01
• 207920F+01	-• 256884E-03	-• 250128E-03	• 301055E+01	• 430023E+01
• 205060F+01	-• 260430E-03	-• 251822E-03	• 294670E+01	• 413192E+01
• 202220F+01	-• 263932E-03	-• 253469E-03	• 288770E+01	• 406630E+01
• 199400E+01	-• 267373E-03	-• 255045E-03	• 282755E+01	• 395287E+01
• 196600E+01	-• 270768E-03	-• 256572E-03	• 276826E+01	• 384204E+01
• 193920E+01	-• 274103F-03	-• 258029E-03	• 270990E+01	• 373336E+01
• 191060E+01	-• 277390F-03	-• 259435E-03	• 265217E+01	• 3622720E+01
• 188320F+01	-• 280617F-03	-• 260772E-03	• 255537E+01	• 352312E+01
• 185600E+01	-• 283797E-03	-• 262057E-03	• 253939E+01	• 342150E+01
• 182900E+01	-• 285917E-03	-• 267272E-03	• 248423E+01	• 332189E+01
• 180220E+01	-• 289339E-03	-• 264475E-03	• 242998E+01	• 322468E+01
• 177560E+01	-• 293001E-03	-• 265529E-03	• 237632E+01	• 312941E+01
• 174920E+01	-• 295964E-03	-• 266570E-03	• 232357E+01	• 303648E+01
• 172300F+01	-• 298869F-03	-• 267542E-03	• 227160E+01	• 294543E+01
• 169700E+01	-• 301725E-03	-• 268464E-03	• 222643E+01	• 205664E+01
• 167120E+01	-• 304522E-03	-• 269314E-03	• 217003F+01	• 276968E+01
• 164560E+01	-• 307271E-03	-• 270108E-03	• 212040F+01	• 268491E+01
• 162020E+01	-• 309962E-03	-• 273838E-03	• 207154E+01	• 260192E+01
• 159500F+01	-• 312605E-03	-• 271513E-03	• 202345F+01	• 252105E+01
• 157000E+01	-• 315199E-03	-• 272123E-03	• 197610E+01	• 244190E+01
• 154520E+01	-• 317726E-03	-• 272672E-03	• 192951E+01	• 236481E+01
• 152060F+01	-• 320206F-03	-• 273168E-03	• 188366F+01	• 228938E+01
• 149620F+01	-• 322639F-03	-• 273603E-03	• 183855F+01	• 221595E+01
• 147200E+01	-• 325015E-03	-• 273975E-03	• 174416F+01	• 214413E+01
• 144800E+01	-• 327343E-03	-• 274292E-03	• 175051E+01	• 207424E+01
• 142420E+01	-• 329617E-03	-• 274547E-03	• 170757E+01	• 200590E+01
• 140060F+01	-• 331844F-03	-• 274747E-03	• 166534F+01	• 193943E+01
• 137720F+01	-• 334017E-03	-• 274806E-03	• 162363E+01	• 187447E+01

• 135400E+01	- 336143F-03	- 274971E-03	- 158301E+01	• 181132E+01	• 348000E+01
• 133100E+01	- 336216E-03	- 274996E-03	- 154269E+01	• 174961E+01	• 345000E+01
• 130820E+01	- 341243F-03	- 274967E-03	- 150345E+01	• 168966E+01	• 342000E+01
• 128560E+01	- 342219F-03	- 274890E-03	- 146470F+01	• 163110E+01	• 339000E+01
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• 124100E+01	- 346029F-03	- 274541E-03	- 138923E+01	• 151672E+01	• 333000E+01
• 121900F+01	- 347864E-03	- 274290E-03	- 135249E+01	• 146684E+01	• 330000E+01
• 119720F+01	- 349650F-03	- 273983E-03	- 131641E+01	• 141226E+01	• 327000E+01
• 117560E+01	- 351392E-03	- 273625E-03	- 128099E+01	• 136125E+01	• 324000E+01
• 115420E+01	- 353086F-03	- 273210E-03	- 124621F+01	• 131149E+01	• 321000E+01
• 113300F+01	- 354737E-03	- 272746E-03	- 121207E+01	• 126326E+01	• 318000E+01
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• 107060E+01	- 359421E-03	- 271037E-03	- 111344E+01	• 112626E+01	• 309000E+01
• 105020E+01	- 360897E-03	- 270367E-03	- 108161E+01	• 108327E+01	• 306000E+01
• 103000E+01	- 362329F-03	- 269644E-03	- 105079F+01	• 104138E+01	• 303000E+01
• 101000F+01	- 363721E-03	- 268875E-03	- 102037E+01	• 100086E+01	• 300000E+01
• 990200E+00	- 365070E-03	- 268054E-03	- 990549E+00	• 961393E+00	• 297000E+01
• 970600E+00	- 366381E-03	- 267186E-03	- 961322E+00	• 923249E+00	• 294000E+01
• 951200F+00	- 367650F-03	- 265270E-03	- 932681F+00	• 886115E+00	• 291000E+01
• 932000F+00	- 368882E-03	- 265307E-03	- 904622F+00	• 850251E+00	• 288000E+01
• 913000F+00	- 370073E-03	- 264296E-03	- 877137E+00	• 815355E+00	• 285000E+01
• 894200E+00	- 371228F-03	- 263240F-03	- 850222E+00	• 781678E+00	• 282000E+01
• 875600E+00	- 372345F-03	- 262137E-03	- 823868E+00	• 748926E+00	• 279000E+01
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• 839000E+00	- 374471F-03	- 259797E-03	- 772826E+00	• 686650E+00	• 273000E+01
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• 803200F+00	- 376456E-03	- 257211E-03	- 723963E+00	• 626350E+00	• 267000E+01
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• 7717200F+00	- 3780839E-03	- 250244E-03	- 611021E+00	• 4989929E+00	• 252000E+01
• 768200F+00	- 378306F-03	- 254592E-03	- 677230E+00	• 573852E+00	• 261000E+01
• 751000E+00	- 379162E-03	- 253184E-03	- 648125E+00	• 657080E+00	• 258000E+01
• 803200F+00	- 380266E-03	- 251735E-03	- 632580E+00	• 626350E+00	• 255000E+01
• 785600F+00	- 380839E-03	- 250244E-03	- 611021E+00	• 4989929E+00	• 252000E+01
• 700600F+00	- 381621F-03	- 248742E-03	- 5899965E+00	• 475593E+00	• 249000E+01
• 684200E+00	- 382374E-03	- 247141E-03	- 5660405E+00	• 453206E+00	• 246000E+01
• 669000F+00	- 383097E-03	- 245530E-C3	- 549336E+00	• 431506E+00	• 243000E+01
• 652000E+00	- 383793E-03	- 243679E-03	- 520751E+00	• 410712E+00	• 240000E+01
• 636200F+00	- 384460E-03	- 242189F-03	- 511645E+00	• 397568E+00	• 237000E+01
• 620600E+00	- 385104E-03	- 240462E-03	- 492011E+00	• 371296E+00	• 234000E+01
• 605200F+00	- 385715E-03	- 238696E-03	- 473844E+00	• 352627E+00	• 231005E+01
• 590000E+00	- 386303E-03	- 2366925E-03	- 456137E+00	• 334785E+00	• 226000E+01
• 575000F+00	- 386967F-03	- 235051F-03	- 4388885F+00	• 317532E+00	• 225000E+01

• 560200E+00	-• 387406E-03	-• 233174F-03	-• 422081E+00	* 301062E+00	* 222200E+01
• 545600E+00	-• 387921E-03	-• 231259E-03	-• 405720E+00	. 285138E+00	. 219000E+01
• 531200E+00	-• 388414E-03	-• 229309E-03	-• 389795E+00	. 269964E+00	. 216000E+01
• 517000E+00	-• 3889A4F-03	-• 227323E-03	-• 374301F+00	. 255302E+00	. 213000E+01
• 503001F+00	-• 389332E-03	-• 225302E-03	-• 359231F+00	. 241354E+00	. 210000E+01
• 489200E+00	-• 389760E-03	-• 223245E-03	-• 344579E+00	. 227668E+00	. 207000E+01
• 475600F+00	-• 390167E-03	-• 221154E-03	-• 330340E+00	. 215098E+00	. 204000E+01
• 462200E+00	-• 390554E-03	-• 219028E-03	-• 316507E+00	. 202759E+00	. 201000E+01
• 449000E+00	-• 390922E-03	-• 216860E-03	-• 303074E+00	. 191062E+00	. 196000E+01
• 436000E+00	-• 391271F-03	-• 214673E-03	-• 290336E+00	. 179785E+00	. 195000E+01
• 423200E+00	-• 391603E-03	-• 212446E-03	-• 277386E+00	. 169118E+00	. 192000E+01
• 410600E+00	-• 391917E-03	-• 210184E-03	-• 265119E+00	. 158841E+00	. 189000E+01
• 398200E+00	-• 392215E-03	-• 207889E-03	-• 253227E+00	. 149140E+00	. 186000E+01
• 386000F+00	-• 392496E-03	-• 205561E-03	-• 241706E+00	. 139802E+00	. 183000E+01
• 374000E+00	-• 392762E-03	-• 203201E-03	-• 230550E+00	. 131009E+00	. 180000E+01
• 362200E+00	-• 393013F-03	-• 200807E-03	-• 219751E+00	. 122550E+00	. 177000E+01
• 350600E+00	-• 393250E-03	-• 198381E-03	-• 209305E+00	. 114606E+00	. 174000E+01
• 339200E+00	-• 393472E-03	-• 195922E-03	-• 199204E+00	. 106970E+00	. 171000E+01
• 328000E+00	-• 393682E-03	-• 193432E-03	-• 189444E+00	. 998183E-01	. 166000E+01
• 317000E+00	-• 393879E-03	-• 190908E-03	-• 180018F+00	. 929502E-01	. 165000E+01
• 306200E+00	-• 394063E-03	-• 186353E-03	-• 170924E+00	. 865372E-01	. 162000E+01
• 295600E+00	-• 394236E-03	-• 185766E-03	-• 162145F+00	. 803832E-11	. 159000E+01
• 285200E+00	-• 394398E-03	-• 183147E-03	-• 153686F+00	. 746566E-11	. 156000E+01
• 275000E+00	-• 394549E-03	-• 180496E-03	-• 145536E+00	. 691653E-11	. 153000E+01
• 265000E+00	-• 394690E-03	-• 177813E-03	-• 137691E+00	. 640743E-01	. 150000E+01
• 255200E+00	-• 394821E-03	-• 175098E-03	-• 130143E+00	. 591968E-01	. 147000E+01
• 245600E+00	-• 394943E-03	-• 172352E-03	-• 122888E+00	. 546939E-01	. 144000E+01
• 236200E+00	-• 395056E-03	-• 169573E-03	-• 115919E+00	. 503917E-01	. 141000E+01
• 227000E+00	-• 395161E-03	-• 166763E-03	-• 109229F+00	. 464197E-01	. 138000E+01
• 218000E+00	-• 395258E-03	-• 163921E-03	-• 102814E+00	. 426277E-01	. 135000E+01
• 209200F+00	-• 395347E-03	-• 161046E-03	-• 966662E-01	. 391621E-01	. 132000E+01
• 200600E+00	-• 395429E-03	-• 159140E-03	-• 907806E-01	. 358466E-01	. 129000E+01
• 192200E+00	-• 395505F-03	-• 155202E-03	-• 851509E-01	. 328347E-01	. 126000E+01
• 184000E+00	-• 395574E-03	-• 152232E-03	-• 797711E-01	. 299539E-01	. 123000E+01
• 176000E+00	-• 395638E-03	-• 149229E-03	-• 746351F-01	. 273550E-01	. 120000E+01
• 168200F+00	-• 395696E-03	-• 146194E-03	-• 697370F-01	. 248690E-01	. 117000E+01
• 160600F+00	-• 395749E-03	-• 143126E-03	-• 650706E-01	. 226442E-01	. 114000E+01
• 153200E+00	-• 395796F-03	-• 140026E-03	-• 606301E-01	. 205151E-01	. 111000E+01
• 146000F+00	-• 395840E-03	-• 136892E-03	-• 564093E-01	. 186274E-01	. 108000E+01
• 139000F+00	-• 395879E-03	-• 133726E-03	-• 524023E-01	. 168192E-01	. 105000E+01
• 132200F+00	-• 395914F-03	-• 130527E-03	-• 4866030E-01	. 152337E-01	. 102000E+01
• 125600F+00	-• 395945E-03	-• 127294E-03	-• 450053F-01	. 137123E-01	. 990000E+00

• 119200E+00	- • 39E 97 3F+03	- • 124027E+03	- • 416034E+01	- • 123958E+01
• 113900E+00	- • 39E 90 9F+03	- • 120727F+03	- • 383911E+01	- • 111291E+01
• 107000E+00	- • 79E 12 2F+03	- • 147393E+03	- • 253624E+01	- • 100504E+01
• 101200E+00	- • 30E 34 0F+03	- • 114024F+03	- • 325113E+01	- • 900810E+02
• 956000E+01	- • 39E 05 7F+02	- • 110621E+03	- • 25310F+01	- • 13794E+02
• 902000E+01	- • 39E 07 2E+03	- • 107183E+03	- • 273178E+01	- • 10000E+02
• 850000E+01	- • 39E 09 6F+03	- • 163711E+03	- • 249634F+01	- • 660285E+02
• 809000E+01	- • 39E 29 7E+03	- • 100222F+03	- • 227625E+01	- • 52635E+02
• 752000E+01	- • 39E 10 7F+03	- • 966575E+04	- • 267090E+01	- • 53325E+02
• 706000E+01	- • 39E 11 5E+03	- • 930774E+04	- • 187971E+01	- • 486194E+02
• 662000E+01	- • 79E 12 2F+03	- • 994611E+04	- • 170265E+01	- • 446116E+02
• 622000E+01	- • 70E 12 8E+03	- • 458082E+04	- • 153733E+01	- • 405247E+02
• 580000E+01	- • 39E 13 3E+03	- • 821183E+04	- • 138495E+01	- • 376243E+02
• 542000E+01	- • 79E 13 7F+03	- • 783912E+04	- • 124471E+01	- • 345572E+02
• 506000E+01	- • 39E 14 0E+03	- • 745255E+04	- • 11483F+01	- • 325676E+02
• 472000E+01	- • 39E 14 3E+03	- • 708239E+04	- • 905818E+02	- • 303330E+02
• 440000E+01	- • 39E 14 5F+03	- • 669629E+04	- • 856763E+02	- • 290769E+02
• 410000E+01	- • 39E 14 6E+03	- • 631032E+04	- • 707032E+02	- • 275067E+02
• 382000E+01	- • 39E 14 8F+03	- • 591846E+04	- • 696022E+02	- • 268257E+02
• 355000E+01	- • 79E 14 9E+03	- • 552264E+04	- • 613139E+02	- • 257711E+02
• 332000E+01	- • 39E 14 9E+03	- • 512295E+04	- • 537755E+02	- • 255264E+02
• 310000E+01	- • 39E 15 0E+03	- • 471945E+04	- • 469292E+02	- • 248578E+02
• 290000E+01	- • 30E 45 0E+03	- • 431116E+04	- • 407139E+02	- • 268225E+02
• 272000E+01	- • 39E 15 1F+02	- • 789919E+04	- • 350693E+02	- • 245364E+02
• 256000E+01	- • 30E 15 1F+03	- • 348307E+04	- • 290352E+02	- • 243823E+02
• 242000E+01	- • 39E 15 1F+03	- • 306277E+04	- • 252511E+02	- • 246151E+02
• 230000E+01	- • 39E 15 1E+03	- • 263625E+04	- • 265565E+02	- • 250370E+02
• 220000E+01	- • 39E 15 1F+03	- • 220946E+04	- • 169921E+02	- • 249404E+02
• 212000E+01	- • 39E 15 1F+03	- • 177636E+04	- • 135965E+02	- • 254346E+02
• 206000E+01	- • 79E 15 1F+03	- • 13331E+04	- • 88982E+03	- • 253974E+02
• 202000E+01	- • 39E 15 1F+03	- • 97563E+05	- • 647173E+02	- • 253203E+02
• 200000E+01	- • 39E 15 1F+03	- • 450774E+05	- • 322189E+02	- • 259094E+02
• 200000E+01	- • 20E 00 0E+03	- • 264382E+02	- • 516152E+01	-