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C File: hthesis.f
C
C Hthesis
C =======

C This document is a reconstruction of the 1982-1983 code "Hthesis"
C underlying GNU C-Graph 2.0. The author, Adrienne Gaye Thompson,
C completed Hthesis in April 1983. Reconstruction is in progress.
C
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C
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C (FFT/IFFT subprogram excluded). Fortran 77 program of dissertation
C "Interactive Computer Package Demonstrating: Sampling Convolution
C and the FFT", submitted April 1983 in partial fulfilment of the
C degree of Bachelor of Science in Engineering (Honours), University
C of Aberdeen, Scotland). Created and developed on the University
C Honeywell 66/80 mainframe - account id UEN4059.
C
C The author's 1983 Dissertation manuscript included the Fortran 77
C code copied from the computer printout by her typist who, directed
C by Engineering faculty members, made unauthorised amendments. Her
C thesis submission consisted of the manuscript and the actual Fortran
C 77 printout, itself, generated by the Honeywell computer. Hthesis
C (reconstructed from the thesis manuscript) is available at:
C <http://www.codeartnow.com/code/download/c-graph-1/c-graph-1-buffet
C /hthesis.f> See also <http://www.codeartnow.com/law-project>.
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C work.
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```
*#FTN GPP=(NWARN,CORE=55K,ULIB) GINO/GRAFLIB;GINO/GINOLIB#GRAGP"08"
      COMMON NB,NP,T,M,P,TL,Y
      CHARACTER*24 A,TP
      INTEGER IP/0000000000077/
      DIMENSION F1(1024),F2(1024),FCON(2048),AT(2048),GMOD1(1024),
      &GFREQ1(1024),GMOD2(1024),GFREQ2(1024),GMOD3(1024),
      &GFREQ3(1024),RMOD(1024)
      CALL FPARAM(3,IP)
C
C
      WRITE(6,4)
 4    FORMAT(////,"SIGNAL THEORY DEMONSTRATION PACKAGE")
      COMPLEX DFT1(1024),DFT2(1024),DFT3(1024)
      CALL SIGNAL
      WRITE(6,10)
 5    FORMAT('The convolution')


 10   FORMAT(" THE CONVOLUTION OF TWO FUNCTIONS IN THE TIME DOMAIN ", /
     &     ,"IS THE INTEGRAL OF THE PRODUCT,", /
     &     ,"            F1(J)*F2(T-J) ", /
     &     ,"WITH RESPECT TO THE DUMMY VARIABLE OF INTEGRATION (J)")
      CALL PARAM(IND)
 1    CALL SIGNAL
      PRINT,"CHOOSE TWO TIME FUNCTIONS"
      CALL AFUN(F1,F2,2,AT)
      CALL RFFT(F1,GMOD1,GFREQ1,DFT1,IND)
      CALL RFFT(F2,GMOD2,GFREQ2,DFT2,IND)
      PRINT,"THE NEXT PLOT SHOWS THE TIME FUNCTIONS AND THEIR FOURIER
     &TRANSFORMS"
C     GOTO 3
      CALL SAVDRA
      CALL DEVICE(8,0)
      CALL DEVPAP(180.,140.,0)
      CALL MGRAF1(F1,AT,IND,10.,102.5,65.,10.,102.5,38.,1)
      CALL MOVTO2(30.,79.5)
      CALL CHAHOL(17HTIME FUNCTION 1*.)
      CALL MGRAF1(F2,AT,IND,100.,102.5,65.,100.,102.5,38.,1)
      CALL MOVTO2(120.,79.5)
      CALL CHAHOL(17HTIME FUNCTION 2*.)
      CALL MGRAF2(GMOD1,GFREQ1,IND,10.,18.,65.,10.,18.,45.)
      CALL MOVTO2(120.,7.)
      CALL CHAHOL(21HFOURIER TRANSFORM 2*.)
      CALL DEVEND
      CALL CALLSS("PLOT 08\\")
      PRINT,"THE NEXT GRAPH SHOWS CONVOLUTION IN THE TIME DOMAIN"
      CALL SAVDRA
      CALL DEVPAP(180.,140.,0)
      CALL SUBCON(F1,F2,FCON,AT)
      CALL MGRAF1(FCON,AT,IND,40.,80.,110.,40.,80.,80.,1)
C
C
      CALL MOVTO2(65.,25.)
```

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```
      CALL CHASIZ(2.,2.)
      CALL CHAHOL(39HDIRECT CONVOLUTION IN THE TIME DOMAIN*.)
      CALL DEVEND
      CALL CALLSS("PLOT 08\\")
      WRITE(6,11)
 11   FORMAT(" CONVOLUTION IN THE TIME DOMAIN AND MULTIPLICATION", /
     &     ,"IN THE FREQUENCY DOMAIN FORM A FOURIER TRANSFORM PAIR.", /
     &     ,"THE NEXT PLOT SHOWS MULTIPLICATION IN THE FREQUENCY DOMAIN"
     &     , /
     &     ,"FOLLOWED BY APPLICATION OF THE INVERSE FOURIER TRANSFORM TO
     &" / /,"PRODUCE THE ORIGINAL TIME DOMAIN CONVOLUTION."
      CALL SAVDRA
      CALL DEVPAP(180.,140.,0)
      CALL MUL(GMOD1,GMOD2,GMOD3)
      CALL MGRAF2(GMOD3,GFREQ2,IND,10.,45.,65.,10.,45.,65.)
      CALL MOVTO2(10.,30.)
      CALL CHASIZ(1.8,1.8)
      CALL CHAHOL(40HMULTIPLICATION IN THE FREQUENCY DOMAIN*.)
      CALL CMUL(DFT1,DFT2,DFT3)
      CALL IFFT(DFT3,IND,NB)
      DO 15 I=1,NB
         RMOD(I)=(REAL(DFT3(I)))
         RMOD(I)=(RMOD(I))*TL
 15   CONTINUE
      CALL MGRAF1(RMOD,AT,IND,100.,77.,65.,100.,77.,65.,1)
      CALL MOVTO2(110.,30.)
      CALL CHASIZ(1.8,1.8)
      CALL CHAHOL(32HCONVOLUTION IN THE TIME DOMAIN*.)
      CALL DEVEND
      CALL CALLSS("PLOT 08\\")
      DO 8 I=1,NB/2
 8    CONTINUE
      STOP
      END
C
C
      SUBROUTINE GETPRM(TEXT,AREPLY,RV)
C     ==================================
      CHARACTER*24 TEXT,AREPLY
C
      RV=0
      PRINT, TEXT
      READ, AREPLY
      DECODE(AREPLY,1,ERR=9) RV
 1    FORMAT(V)
      RV=ABS(RV)
 9    RETURN
      END
C
C
```

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```
      SUBROUTINE SIGNAL
C     ==================
      WRITE(6,10)
 10   FORMAT("THE FOLL. SIGNALS ARE AVAILABLE AS FUNCTIONS OF TIME", //
     &     ,"TIME FUNCTION                   CODE   ", /
     &     ,"SINE WAVE                         J    ", /
     &     ,"COSINE WAVE                       K    ", /
     &     ,"TRIAGULAR WAVE                    L    ", /
     &     ,"RECTANGULAR WAVE                  M    ", /
     &     ,"EXPONENTIAL                       N    ", /
     &     ,"UNIT STEP                         O    ", /
     &     ,"RAMP                              P    ")
      RETURN
      END
C
C
      SUBROUTINE PARAM(IND)
C     =====================
      COMMON NB,NP,T,M,P,TL,Y
      CHARACTER*24 TP,A
 1    WRITE(6,15)
 15   FORMAT(///
     &     ,"THE NUMBER OF SAMPLES CAN BE ANY EVEN INTEGER BETW EEN", /
     &     ."64 AND 1024 WHICH CAN BE REPRESENTED BY AN INDEX TO BASE 2"
      TP="INDEX"
      CALL GETPRM(TP,A,R)
      IF(R.EQ.0)GOTO 2
      IF(R.GT.10) GOTO 3
      IF(R.LT.6) GOTO 3
      IND=IFIX(R)
      TP="SAMPLE LENGTH"
      CALL GETPRM(TP,A,TL)
      IF(TL.EQ.0) GOTO 2
      PRINT,"IF BOTH FUNCTIONS ARE APERIODIC TYPE 1 FOR PERIOD"
      TP="PERIOD"
      CALL GETPRM(TP,A,P)
      IF(P.EQ.0) GOTO 2
      NB=POW(2,IND)
      T=TL/FLOAT(NB-1)
      M=IFIX(TL/P)
      NP=IFIX(NB*P/TL)
      Y=2*3.14159/P
      GOTO 5
 2    PRINT,"ERROR!! PARAMETER NON-NUMERIC, TRY AGAIN"
      GOTO 1
 3    PRINT,"INDEX NOT IN ALLOWED RANGE, TRY AGAIN"
C
C
      GOTO 1
 5    RETURN
      END
C
```

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```
C
      SUBROUTINE AFUN(F1,F2,K,AT)
C     ============================
      COMMON NB,NP,T,M,P,TL,Y
      DIMENSION F(1024),F1(1024),F2(1024),AT(1024)
      CHARACTER*24 TP,A
 4    IF(K.EQ.1) TP="TIME FUNCTION"
      IF(K.EQ.2) TP="TIME FUNCTION1"
 2    CALL GETPRM(TP,A,R)
      IF(A.EQ."J") CALL SI(NB,Y,T,F,AT,$1)
      IF(A.EQ."K") CALL CO(NB,Y,T,F,AT,$1)
      IF(A.EQ."L") CALL TRI(NB,NP,T,P,F,AT,M,TL,$1)
      IF(A.EQ."M") CALL RECT(NB,NP,T,P,F,AT,M,TL,$1)
      IF(A.EQ."N") CALL EXPO(NB,T,F,AT,$1)
      IF(A.EQ."O") CALL STEP(0,NB,T,F,AT,$1)
      IF(A.EQ."P") CALL RAMP(NB,T,F,AT,$1)
 3    PRINT,"ERROR!!CODE NOT IN EXPECTED RANGE. TRY AGAIN"
      IF(K.LE.2) GOTO 4
      IF(K.LE.3) GOTO 5
 1    CONTINUE
      DO 10 I=1,NB
         IF(K.LE.2) F1(I)=F(I)
C     IF(K.LE.2) PRINT,F1(I)
         IF(K.LE.3) F2(I)=F(I)
C     IF(K.LE.3) PRINT,F2(I)
 10   CONTINUE
      K=K+1
      IF(K.EQ.2) GOTO 3
      IF(K.EQ.3) GOTO 5
      IF(K.EQ.4) GOTO 3
 5    TP="TIME FUNCTION2"
      GOTO 2
 3    DO 6 I=1,NB
 6    CONTINUE
      RETURN
      END
C
C
      SUBROUTINE IFFT(A,N,NB)
C     =========================
C     Excluded from Hthesis Copyright claim:
C     FFT code from "An Introduction to Random Vibrations and Spectral
C     Analysis" (p. 220), by D. E. Newland, 1975, London, Longman.
C     Authors - J.W. Cooley, P. Lewis and P. Welch, "The Fast Fourier
C     Transform and its Applications", IEEE Transactions on Education
C     12, 1, p. 29, fig. 5. Copyright 1969 by the IEEE.
C
      COMPLEX A(NB),U,W,T
C     REORDER SEQUENCE
      NBD2=NB/2
      NBM1=NB-1
      J=1
      DO 4 L=1,NBM1
```

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```
C
         IF(L.GE.J) GOTO 2
         T=A(J)
         A(J)=A(L)
         A(L)=T
 2       K=NBD2
 3       IF(K.GE.J) GOTO 4
         J=J-K
         K=K/2
         GOTO 3
 4       J=J+K
C     CALCULATE FFT ACCORDING TO FIG 12.5
C
         PI=3.141592653589793
         DO 6 M=1,N
            U=(1.0,0.0)
            ME=2**M
            K=ME/2
            W=CMPLX(COS(PI/K),+SIN(PI/K))
            DO 6 J=1,K
               DO 5 L=J,NB,ME
                  LPK=L+K
                  T=A(LPK)*U
                  A(LPK)=A(L)-T
 5                A(L)=A(L)+T
 6                U=U*W
                  RETURN
                  END
C
C
      SUBROUTINE FFT(A,N,NB)
C     ========================
C     Excluded from Hthesis Copyright claim:
C     FFT from "An Introduction to Random Vibrations and Spectral
C     Analysis" (p. 220), by D. E. Newland, 1975, London, Longman.
C     Authors - J.W. Cooley, P. Lewis and P. Welch, "The Fast Fourier
C     Transform and its Applications", IEEE Transactions on Education
C     12, 1, p. 29, fig. 5. Copyright 1969 by the IEEE.
C
      COMPLEX A(NB),U,W,T
C     DIVIDE ALL ELEMENTS BY NB
      DO 1 J=1,NB
 1       A(J)=A(J)/NB
C     REORDER SEQUENCE
         NBD2=NB/2
         NBM1=NB-1
         J=1
         DO 4 L=1,NBM1
C
C
            IF(L.GE.J) GOTO 2
            T=A(J)
            A(J)=A(L)
```

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```
            A(L)=T
 2          K=NBD2
 3          IF(K.GE.J) GOTO 4
            J=J-K
            K=K/2
            GOTO 3
 4          J=J+K
C     CALCULATE FFT ACCORDING TO FIG 2.3
            PI=3.141592653589793
            DO 6 M=1,N
               U=(1.0,0.0)
               ME=2**M
               K=ME/2
               W=CMPLX(COS(PI/K),-SIN(PI/K))
               DO 6 J=1,K
                  DO 5 L=J,NB,ME
                     LPK=L+K
                     T=A(LPK)*U
                     A(LPK)=A(L)-T
 5                   A(L)=A(L)+T
 6                   U=U*W
                     RETURN
                     END
C
C
      SUBROUTINE RECT(NB,NP,T,P,F,AT,M,TL,*)
C     ======================================
C     THIS SUBPROGRAM GENERATES A RECTANGULAR WAVE
C     SAMPLE LENGTH TL, SAMPLE INTERVAL T,PERIOD P, NO. OF CYCLES M,
C     NO. OF DATA POINTS NB, ETC.
      DIMENSION F(1024, AT(1024)
      DO 30 I=1,M+1
         L=I-1
         DO 10 K=1,3*NP/4
            J=K-1
            N=K+L*NP
            AT(N)=J*T+L*P
            IF(AT(N).GT.TL) GOTO 10
            IF(K.LE.NP/4) F(N)=0
            IF(K.GT.NP/4) F(N)=10
C     WRITE(7,5) AT(N),F(N)
 5          FORMAT(F10.5,5X,F10.5)
 10      CONTINUE
         DO 20 J=3*NP/4+1,NP
            JN=J+L*NP
            AT(JN)=(J-1)*T+L*P
            IF(AT(JN).GT.TL) GOTO 20
            F(JN)=0
 20      CONTINUE
 30   CONTINUE
      RETURN 1
      END
      SUBROUTINE TRI(NB,NP,T,P,F,AT,M,TL,*)
```

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```
C     ========================================
C     THIS SUBPROGRAM GENERATES A TRIANGULAR WAVE
C     SAMPLE LENGTH TL, SAMPLE INTERVAL T, PERIOD P,
C     NO. OF SAMPLES NB, ETC., ETC.
      DIMENSION F(1024, AT(1024)
      DO 20 I=1,M+1
         L=I-1
         DO 10 K=1,NP
            J=K-1
            N=K+L*NP
            IF(N.GT.NB) GOTO 8
            AT(N)=J*T+L*P
            IF(K.LE.NP/2) F(N)=AT(N)-P*L-P/4
            IF(K.GT.NP/2) F(N)=P*I-AT(N)-P/4
 9          IF(I.LT.M+1.OR.K.LT.NP) GOTO 10
C     TRUNCATION ERROR CORRECTION
            IC=NB-N
            DO 7 NC=1,IC
               AT(N+NC)=AT(N)+NC*T
               IF(K.LE.NP/2) F(N+NC)=AT(N+NC)-P*M-P/4
               IF(K.GT.NP/2) F(N+NC)=P*(M+1)-AT(N+NC)-P/4
 7          CONTINUE
 8          CONTINUE
 10      CONTINUE
 20   CONTINUE
      RETURN 1
      END
C
C
      SUBROUTINE SI(NB,Y,T,F,AT,*)
C     ==============================
C     THIS SUBROUTINE GENERATES A SINE WAVE
      DIMENSION F(1024),AT(1024)
      DO 10 I=1,NB
         J=I-1
         F(I)=(SIN(Y*J*T))
         AT(I)=J*T
 10   CONTINUE
      RETURN 1
      END
C
      SUBROUTINE CO(NB,Y,T,F,AT,*)
C     ==============================
C     THIS SUBROUTINE GENERATES A COSINE WAVE
      DIMENSION F(1024),AT(1024)
      DO 10 I=1,NB
         J=I-1
         F(I)=(COS(Y*J*T))
         AT(I)=J*T
 10   CONTINUE
      RETURN 1
      END
C
```

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```
C
      SUBROUTINE EXPO(NB,T,F,AT,*)
C     ==============================
      DIMENSION F(1024),AT(1024)
      DO 10 I=1,NB
         J=I-1
         AT(I)=J*T
         F(I)=EXP(-J*T)
 10   CONTINUE
      RETURN 1
      END
C
C
      SUBROUTINE STEP(B,NB,T,F,AT,*)
C     ===============================
      DIMENSION F(1024),AT(1024)
      DO 10 I=1,NB
         J=I-1
         AT(I)=J*T
         IF(AT(I).LE.B) F(I)=0
         IF(AT(I).GT.B) F(I)=1
 10   CONTINUE
      RETURN 1
      END
C
C
      SUBROUTINE RAMP(NB,T,F,AT,*)
C     ==============================
      DIMENSION F(1024),AT(1024)
      DO 10 I=1,NB
         J=I-1
         AT(I)=J*T
         F(I)=AT(I)
 10   CONTINUE
      RETURN 1
      END
C
C
      SUBROUTINE SUBCON(F1,F2,FCON,AT)
C     ==================================
      COMMON NB,NP,T,M,P,TL,Y
      DIMENSION F1(1024),F2(1024),FCON(2048),AT(2048),R1(1024),
     &     R2(1050),RCON(1050),RFCON(1050)
      CALL CONV(NB,F1,F2,FCON,T)
      CALL REV(F2,R2,NB)
      CALL REV(F1,R1,NB)
      CALL CONV(NB,R1,R2,RCON,T)
      CALL REV(RCON,RFCON,NB)
      DO 60 I=1,NB
         J=NB+(I-1)
C
C
         FCON(J)=RFCON(I)
```

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```
         AT(J)=AT(I)+((NB-1)*T)
 60   CONTINUE
      DO 10 I=1,2*NB
 10   CONTINUE
      RETURN
      END
C
C
      SUBROUTINE CONV(NB,F1,F2,CON,T)
C     ================================
      DIMENSION F1(1024),F2(1024),CON(1024),AT(1024)
      DO 40 I=I, NB
         IJ=I-1
         AT(I)=(IJ-NB/2)*T
         CON(I)=0
         DO 40 J=1,I
            K=I-(J-1)
            CON(I)=CON(I)+(F1(J)*F2(K))*T
 40      CONTINUE
         RETURN
         END
C
C
      SUBROUTINE REV(F,R,NB)
C     ======================
      DIMENSION F(1050),R(1050)
      DO 70 I=1,NB
         J=NB-(I-1)
         R(I)=F(J)
 70   CONTINUE
      RETURN
      END
C
C

      SUBROUTINE MUL(F1,F2,AMUL)
C     ==========================
      DIMENSION F1(1024),F2(1024),AMUL(1024)
      COMMON NB,NP,T,M,P,TL,Y
      DO 10 I=1,NB
         AMUL(I)=F1(I)*F2(I)
 10   CONTINUE
      RETURN
      END
C
C
```

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```
      SUBROUTINE CMUL(D1,D2,D3)
C     ==========================
      COMPLEX D1(1024),D2(1024),D3(1024)
      COMMON NB,NP,T,M,P,TL,Y
      DO 10 I=1,NB
         D3(I)=D1(I)*D2(I)
 10   CONTINUE
      RETURN
      END
C
C
      SUBROUTINE RFFT(F,GMOD,GFREQ,DFT,IND)
C     =====================================
      COMMON NB,NP,T,M,P,TL,Y
      DIMENSION RMOD(1024),RRMOD(1024),GMOD(1024),F(1024), FREQ(1024)
     &     ,RFREQ(1024),GFREQ(1024)
      COMPLEX DFT(1050)
      PI=3.141592653589793
      DO 60 I=1,NB
         DFT(I)=CMPLX(F(I),0.0)
 60   CONTINUE
      CALL FFT(DFT,IND,NB)
      DO 70 I=1,NB
         RMOD(I)=CABS(DFT(I))
 70   CONTINUE
      DO 40 I=1,NB
         FREQ(I)=(2*PI*I)/(NB*T)
 40   CONTINUE
      DO 80 I=NB/2+1,NB
         FREQ(I)=FREQ(I)-FREQ(NB)
 80   CONTINUE
      J=NB/2+1
      DO 90 I=1,NB
         IF(J.EQ.NB+1) J=1
         RFREQ(I)=FREQ(J)
         RRMOD(I)=RMOD(J)
         J=J+1
 90   CONTINUE
      K=1
      DO 50 I=NB/2+1,NB
         GMOD(K)=RRMOD(I)
         GFREQ(K)=RFREQ(I)
         K=K+1
 50   CONTINUE
      RETURN
      END
C
C
```

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```
      SUBROUTINE MGRAF1(F,AT,IND,XXOR,XYOR,XAXLEN,YXOR,YYOR,YAXLEN,K)
C     ================================================================
      COMMON NB,NP,T,M,P,TL,Y
      DIMENSION F(2048),AT(2048)
      S=0.
      FVE1=AT(K*NB)
      FVE2=0
C     THIS LOOP FINDS THE MAXIMUM VALUE IN ARRAY F
      DO 7 I=1,K*NB
         FVE2=AMAX1(F(I),FVE2)
 7    CONTINUE
      CALL CHASIZ(1..5,1.5)
      CALL AXIPOS(1,XXOR,XYOR,XAXLEN,1)
      CALL AXIPOS(0,YXOR,YYOR,YAXLEN,2)
      CALL AXISCA(1,IND,0.,FVE1,1)
      CALL AXISCA(1,IND,-FVE2,FVE2,2
      CALL AXIDRA(0,0,1)
      CALL AXIDRA(0,0,2)
      CALL GRAPOL(AT,F,K*NB)
      FRINT1=(FVE1/FLOAT(IND-1))
      FRINT2=(FVE2/FLOAT(IND-1))
      DO 23 I=1,IND
         CALL GRAMOV((I-1)*FRINT1,0.)
         CALL GRALIN((I-1)*FRINT1,2*(-FVE2/90.))
         CALL GRAMOV(((I-1)*FRINT1)-(FVE1/(K*NB-1)),9*(-FVE2/90.))
         CALL CHAFIX((I-1)*FRINT1,4,1)
 23   CONTINUE
 26   DO 25 I=1,IND
         CALL GRAMOV(0.,(I-1)*FRINT2)
         CALL GRALIN(2*(-FVE1/120.),(I-1)*FRINT2)
         CALL GRAMOV(15*(-FVE1/120.),(I-1)*FRINT2+(FVE2/(K*NB-1)*1.5))
         CALL CHAFIX((I-1)*FRINT1,4,1)
 25   CONTINUE
      IF(S.EQ.1) GOTO 27
      FRINT2=-FRINT2
      S=1.0
      GOTO 26
 27   CALL CHAANG(90.)
      CALL GRAMOV(-AT(k*NB)/12,0.)
      CALL CHAHOL(6HF(T)*.)
      CALL CHAANG(0.0)
      CALL GRAMOV(3*AT(K*NB)/4,-FVE2)
      CALL CHAHOL(15HT*TIMEIN SEC*.)
      RETURN
      END
C
C
```

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```
      SUBROUTINE MGRAF2(GMOD,GFREQ,IND,XXOR,XYOR,XAXLEN,YXOR,YYOR
     &     ,YAXLEN)
C     ============================================================
      COMMON NB,NP,T,M,P,TL,Y
      DIMENSION GMOD(512),GFREQ(512)
      VE1=GREQ(NB/2)
      VE2=0
      THIS LOOP FINDS THE MAXIMUM VALUE IN ARRAY GMOD
      DO 9 I=1,NB/2
         VE2=AMAX1(GMOD(I),VE2)
 9    CONTINUE
      CALL CHASIZ(1.5,1.5)
      CALL AXIPOS(0,XXOR,XYOR,XAXLEN,1)
      CALL AXIPOS(0,YXOR,YYOR,YAXLEN,2)
      CALL AXISCA(1,IND,0.,VE1,1)
      CALL AXISCA(1,IND,0.,VE2,2)
      CALL AXIDRA(0,0,1)
      CALL AXIDRA(0,0,2)
      DO 19 I=1,NB/2
         GF=GFREQ(I)
         GM=GMOD(I)
         CALL GRAMOV(GF,GM)
         CALL GRALIN(GF,0)
 19   CONTINUE
      RINT1=(VE1/FLOAT(IND-1)
      RINT2=(VE2/FLOAT(IND-1)
      DO 17 I=1,IND
         CALL GRAMOV((I-1)*RINT1,0.)
         CALL GRALIN((I-1)*RINT1,2*(-VE2/145.))
         CALL GRAMOV(((I-2)*RINT1)-(VE1/(NB/2-1)),9*(-VE2/145.))
         CALL CHAFIX((I-1)*RINT1,4,1)
 17   CONTINUE
      DO 21 I=1,IND
         CALL GRAMOV(0,(I-1)*RINT2)
         CALL GRALIN(2*(-VE1/200.),(I-1)*RINT2)
         CALL GRAMOV(22*(-VE1/200.),(I-1)*RINT2+(VE2/((NB/2-1)*7)))
         CALL CHAFIX((I-1)*RINT2,4,1)
         G=GMOD(NB)
         CALL GRAMOV(3.*G/4.,-VE2/4)
         CALL CHAHOL(11H*LW RAD/S*.)
         CALL CHAANG(90.)
         CALL GRAMOV(-G/5.VE2/3)
         CALL CHAHOL(14H*LL*UX*L(W)L*.)
         CALL CHAANG(0.)
 21   CONTINUE
      RETURN
      END
```