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DECUS NO.	FOCAL8-82
TITLE	PHYSICAL SINE CURVE PROGRAMS
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SOURCE LANGUAGE	FOCAL

PHYSICAL SINE CURVE PROGRAMS

DECUS Program Library Write-up

DECUS No. FOCAL8-82

FOCAL -

PHYSICAL SINE CURVE PROGRAMS

CONSISTING OF:

SIMPLE SINE MAN

DAMPED SINE ON AXIS

SUM SHADED SINES

PLOT AND ADD TWO PHYSICAL SINE CURVES

FOURIER SYNTHESIS OF A SQUARE WAVE

FOCAL -

SIMPLE SINE MAN

ABSTRACT:

This FOCAL program plots a sine curve according to the input parameters:

OMEGA
TEE ZERO
AMPLITUDE
NUMBER OF DEGREES BETWEEN DATA
NUMBER OF CYCLES DESIRED

The plotted base line is centered on the page using the symbol specified in line 02.02. The datum is plotted by counting form the left margin. Since this would produce a rounding error with respect to the offset base line,(axis) the IF statement of group 4 leads to the appropriate correction.

This routine leads to a very symmetrical looking sinusoidal display because of the form of the equation used.

Lines 01.06, 01.07, and 01.08 provide an amplitude scale prior to plotting.

```
C-FOCAL , 5/63

01.01 T "SIMPLE SINE MAN"!
01.02 S PI=3.14159; A "OMEGA",W,"T0",T0,"AMPLITUDE",A,!
01.04 A "PLOT EVERY [ ? ] DEGREES",DG,"FOR [ ? ] CYCLES",CY,!
01.06 F K=0,[35-(A+1)];T " "
01.07 T "A"; F L=0,2*A-2;T ":"
01.08 S Z=0;T "A",!
01.10 F T=0,DG*PI/180,CY*2*PI; DO 2; DO 4; T "*"; DO 1.3; T !
01.30 S Z=Z+1; T #,%3,Z,%2,Y-35

02.01 F Y=0,34; T " "
02.02 T ":",#
02.03 R

04.02 I ([W*T-T0]-PI)4.05,4.05,4.04
04.04 F Y=0,35+A*FSIN(W*T-T0); T " "; R
04.05 F Y=0,34+A*FSIN(W*T-T0); T " "; R
```

```
C
SINGLE SINE RAN
DEGREE?1 T?30 AMPLITUDE?25
PLOT EVERY [ ? ] DEGREES?15 FOR [ ? ] CYCLES?1.5
            A:::::::::::::::::::::::::::::::::::::::::::::::::A
=    1=  0                           *
=    2=  6                           :     *
=    3= 12                           :           *
=    4= 17                           :                *
=    5= 21                           :                    *
=    6= 24                           :                       *
=    7= 25                           :                        *
=    8= 24                           :                       *
=    9= 21                           :                    *
=   10= 17                           :                *
=   11= 12                           :           *
=   12=  6                           :     *
=   13=  0                           *
=   14=- 6                       *     :
=   15=-12                 *           :
=   16=-17            *                :
=   17=-21        *                    :
=   18=-24     *                       :
=   19=-25  *                          :
=   20=-24     *                       :
=   21=-21        *                    :
=   22=-17            *                :
=   23=-12                 *           :
=   24=- 6                       *     :
=   25=  0                           *
```

FOCAL -

DAMPED SINE ON AXIS

ABSTRACT:

This FOCAL program improves the listing in

INTRODUCTION TO PROGRAMMING (DEC)

In addition to their obvious plotting function, groups 2 & 3 correct for the rounding error that results from the base line offset, and ensures symmetry about the base line.

```
C-FOCAL , 8/68

01.02 T "DAMPED SINE ON AXES",!
01.03 ASK "SINE WAVE AMPLITUDE", AMPL,!
01.04 ASK "DAMPING FACTOR COEFFICIENT", T,!
01.05 F A=0,71; TYPE "."
01.06 T !; F I=0,.5,15; DO 1.11; T "*"; DO 3
01.07 QUIT
01.11 F J=0,34+AMPL*FSIN(I)*FEXP(-T*I); DO 2; T " "

02.10 I (J-35) 2.3,2.2,2.3
02.20 T ":"
02.30 RETURN

03.10 I (34-J) 3.3,3.2; F K=J,33; T " "
03.20 T ":"
03.30 T !; RETURN
```

FOCAL -

SUM SHADED SINES

ABSTRACT:

This FOCAL program plots the resultant waveform for two sine waves of the same amplitude, subject to the same damping, as the result of their superposition (addition).

The area under the curve is shaded + on the positive side of the base line, and - on the negative side.

This program is intended to plot sufficient points to enable the operator to sketch the resultant curve.

It might also be used as a source of data for the Fourier analysis of a fairly simple periodic function.


```
C-FOCAL , V2A0

01.01 T "SUM SHADED SINES"!!
01.02 C DOCUMENTED SUM OF 1,2 ISO-AMPLITUDE WAVES W/DAMPING
01.03 A "GIVE PHASE ANGLE (DEG.& TENTHS)",THETA,!; DO 5
01.04 S Z=0
01.05 A "SINE WAVE AMPLITUDE",AMPL,!
01.06 A "DELTA T / PI LINE [0<=?=>+1]",SCALE,!
01.07 A "DAMPING FACTOR COEFFICIENT",I,!
01.08 A "APPROX. NUMBER OF PI LINES IN THIS PLOT [+-1]",N,!
01.09 F K=0,34;T "-"; C MARKS CONVENTIONAL 'Y'- AXIS
01.10 T ":"; F K=0,33; T "+"
01.11 T !; F T=0,SCALE,(SCALE*N); DO 1.15; T "X"; DO 3
01.13 T "GIVE ME A 'GO' TO PLOT ANOTHER"!
01.14 T "WILL YOU DRAW THE CURVE ON THE ONE ABOVE"!!!!!; DO 4
01.15 F J=0,34+AMPL*(FSIN(I)+FSIN(I*THETA))*FEXP(-T*I); DO 2
01.16 C FINDS DATUM

02.01 I (J-35).03,2.05,2.07
02.03 T " "; S
02.05 T ":"; R
02.07 T "+"; S
02.09 C FINDS X- AXIS IF BEFORE DATUM

03.01 I (34-J)3.03,3.09; F K=J,33; T "-"
03.09 T ":"
03.03 S Z=Z+1 ; T #,%3,Z,%2,J-35,!; R
03.04 C FINDS X- AXIS IF AFTER DATUM

04.01 QUIT

05.01 S PI=3.14159; THETA=(THETA*PI)/180; R
```

FOCAL -

PLOT AND ADD TWO PHYSICAL SINE CURVES

ABSTRACT:

The superposition of simple waveforms to form more complex envelopes is a fundamental skill required for the wave description of physical phenomena. While the graphical approach to superposition provides the quickest insight, and plotting by hand the surest demonstration of proficiency, the time required for sufficient development of long continuous wave trains for a variety of parameters is excessive when plotted by hand. A TTY print-out can be used to speed up the plotting if it is remembered that typing can only be accomplished to the nearset whole line and whole space.

This FOCAL program will plot two individual sine curves and their sum superimposed (in time) on the same base line (axis). Input consists of the amplitudes of the two waves, and their wavelength ratio. One wave will always plot at constant wavelength, and will be shaded + or - under the curve. The other sine curve is found more rapidly since the base line is already defined. The summary waveform is plotted on the third pass on the TTY line, and the fourth pass completes the coordinate table for the resultant waveform.

The baseline is centered on the page. The sum of the two wave amplitudes must not exceed 35 (less than this to avoid overprinting of the resultant table). Comments in the program itself give an approximate indication of the function of each group of instructions. Lines 01.17, 01.18, and 01.19 establish an amplitude scale prior to plotting.

Since the count for all plotting excursions is taken from the left margin, lines 05.01, and 06.01 make the corrections necessary to avoid rounding errors and maintain symmetry with respect to the base line.

There are fundamentally two ways in which a periodic function can be plotted with respect to a base line which is also plotted. One obvious way is to space to the base line, return, and then space to the datum. The approach used here evaluates (on the first pass only) each space to determine if printing is required for the datum, or the axis, or the shading under the curve. While this method requires more time for the first pass, there is no overprinting of the axis, the curve, or the area shaded under the curve. The excursions to plot the second wave and the sum might print over the existing display. The choice of plotting symbols serves to make this overprinting discernable.

```
0-FOCAL , 5/4-4

01.01 T "PLOT AND ADD TWO PHYSICAL SINE CURVES--FOT. APPL.<35"!;S Z=0
01.03 A "WAVE ONE AMPLITUDE",A1,"WAVE TWO AMPLITUDE",A2,!
01.05 T "CONSIDER WAVE ONE OF FIXED WAVELENGTH",!
01.09 A "RATIO OF LAMBDA ONE/LAMBDA TWO",L,!
01.11 A "APPROX.NUMBER OF IT LINES IN THIS PLOT (+-1)",N,!
01.12 T "#1 IS  * WITH -&+",!,"#2 IS  0",!,"SUM PLOTS  X",!!
01.17 T "- AMPLITUDE";F K=0,23;T "<";
01.18 T "."*2*K=0,25;T ">"
01.19 T "AMPLITUDE +"
01.20 T !,"TABLE FOR",!,"RESULTANT",!,"WAVEFORM:"

02.10 T !;F I1=0,3.5,(N+.5*N); DO 2.16;T "*"; DO 6;DO 7;DO 8
02.12 T "GIVE A 'GO' IF YOU WANT ANOTHER PLOT"!
02.14 T "WHILE YOU STUDY THE ONE ABOVE"!!!!!; DO 4
02.16 F J1=0,34+A1*FSIN(I1);DO 5
02.18 C FINDS DATUM ONE

04.10 QUIT

05.01 T (J1-35)5.03,5.06,5.07
05.03 T " "; R
05.05 T ":";R
05.07 T "+"; R
05.08 C FINDS X- AXIS IF BEFORE DATUM ONE

06.01 T (34-J1)6.03,6.02; F V=J1,33; T "-"
06.02 T ":"
06.03 T #;R
06.04 C FINDS X- AXIS IF AFTER DATUM ONE

07.20 S I2=L*I1;DO 7.26;T "O";
07.23 T #;R
07.26 F J2=0,34+A2*FSIN(I2);T " "
07.28 C FINDS DATUM TWO

08.10 T #;S Z=(J1+J2-70); DO 8.12; T "X"
08.11 S Z=Z+1; T #,43,Z,X2,J3-35,!;R
08.12 F J3=0,34+0; T " "
08.14 C FINDS DATA SUM
```

```
RUN
PLOT AND ADD TWO PHYSICAL SINE CURVES--TOT. AMPL.<35
WAVE ONE AMPLITUDE?8 WAVE TWO AMPLITUDE?16
CONSIDER WAVE ONE OF FIXED WAVELENGTH
RATIO OF LAMBDA ONE/LAMBDA TWO?0.5
APPROX.NUMBER OF TT LINES IN THIS PLOT [+-1]?100
#1 IS  * WITH -&+
#2 IS  0
SUM PLOTS  X

- AMPLITUDE<<<<<<<<<<<<<<<<<<<<<<.>>>>>>>>>>>>>>>>>>>>>>AMPLITUDE+
TABLE FOR
RESULTANT
WAVEFORM:
=    1=  0                              @
=    2=  6                              +++@  X
=    3= 13                              +++++++0      X
=    4= 17                              +++++++*  0       X
=    5= 20                              +++++++*      0       X
=    6= 19                              +++++*            0   X
=    7= 16                              +*                0X
=    8= 12                           *---              X  0
=    9=  7                        *--------         X       0
=   10=  4                        *---------    X         0
=   11=  1                        *---------X         0
=   12=  0                          *------X      0
=   13=- 1                             *-X- 0
=   14=- 1                              0X+*
=   15=- 1                           0    X++++++
=   16=- 3                     0        X  +++++++*
=   17=- 6                  0        X     +++++++*
=   18=- 9               0       X         +++++++
=   19=-13            0  X               +++*
=   20=-17           X0                  *-
=   21=-21       X     0              *------
=   22=-22     X         0        *---------
=   23=-20       X         0     *---------
=   24=-17           X         0*---------
=   25=-10                    X    @------
=   26=- 2                            X@-
=   27=  6                              +++@  X
=   28= 13                              +++++++0      X
=   29= 17                              +++++++*  0       X
=   30= 20                              +++++++*      0       X
=   31= 20                              ++++++            0     X
=   32= 16                              +*                0X
=   33= 12                           *---              X  0
=   34=  8                        *------           X     0
=   35=  4                        *---------    X         0
=   36=  1                        *---------X         0
=   37=- 1                          *------X-      0
```

FOCAL -

FOURIER SYNTHESIS OF A SQUARE WAVE

ABSTRACT:

Fourier descriptions form a pivotal consideration in many physical investigations involving wave notation; even in the investigation of crystal structure and the fundamental nature of matter.

The fundamental mathematical proposal states that any periodic waveform can be synthesized by or analyzed into the sum of an appropriate series of sinusoidal terms. Perhaps the most interesting test of this principle involves the synthesis or analysis of a square wave. Both the synthesis and the analysis are routinely accomplished with 3 to 5 terms using physical (electronic) analogs, even in secondary physics classes.

This FOCAL program will first of all calculate and plot on the TTY page one cycle of the sine curve specified by the input parameters; then it will successively calculate and plot, add, and then plot - - - for each odd harmonic appropriately reduced in amplitude. This process will continue until the display has been made for the maximum number of Fourier terms specified by the input. Once the symmetry of one complete cycle has been observed, line 02.06 may be modified to call for the display of one half cycle (or less) in order to speed up the display when a large number of terms are to be summed.

Alternatively, once the parameters of group 1 have been set (and not subsequently erased by program modification), DO 2 will cuase the separate display of the resultant waveform for the number of Fourier terms specified without continuing to other displays. This enables the operator to individually try out the summation of large numbers of terms.

The IF statements in groups 11 and 12 lead to the appropriate correction for the rounding error that would otherwise result since the base line is offset from the left margin, while all plotting actually references the left margin. Uniformly changing the coefficients 35 and 34 will reposition the plotted baseline to allow greater amplitude for the display of a half cycle or less of the waveform. The SET command in 12.03 accomplishes the summation for each angular position of the specified N terms of the Fourier Series:

$$b \sin a + \frac{b}{3} \sin 3a + \frac{b}{5} \sin 5a + + + +$$

The author has so far examined the first 100 sets of data from the summation of 500 terms of the series (for each datum) taken every 0.01 degrees. This required 16 hours on the PDP-8/S and was therefore preserved on paper tape.

```
C-FOCAL , 8/68

01.02 T "FOURIER SYNTHESIS OF A SQUARE WAVE"!
01.03 T "RECURSIVE TO THE NUMBER OF TERMS SPECIFIED"!!
01.04 S PI=3.14159; A "AMPLITUDE",A,"TERMS IN FOURIER SERIES",L,!
01.06 S N=0;S Y1=0;A "PLOT EVERY [?] DEGREES",DG,!
01.07 T "NEW COMPONENT PLOTS *, SUMMARY WAVEFORM PLOTS 0"!!!!!!
01.08 F Q=1,L;S N=N+1;D 1.10;D 10.1
01.09 T !!"VARY THE PARAMETERS AND I'LL PLOT ANOTHER"!!!!!!!!!!!!!;Q
01.10 T !!"WAVEFORM DISPLAY IF FOURIER SERIES TERMS",N,!;S Z=0

02.01 C [Q 2] WILL DISPLAY N TERMS WITH PARAMETERS OF RECORD
02.02 A "GIVE N FOR THE SEPARATE DISPLAY OF N TERMS",N;D 1.1;D 2.06
02.04 T !!!!!!!!!!!!!;G 2.02
02.06 F T=0,DG*PI/180,2*PI;D 12;T "X",#;D 10.14

10.10 F T=0,DG*PI/180,2*PI;D 11;T "*",#;D 12;T "O",#;D 10.14
10.14 S Z=Z+1;T %3,Z,%2,Y1,!

11.02 S Y=(1/[2*N-1])*A*FSIN(<2*N-1>*T)
11.06 I (Y)11.06,11.10,11.10
11.08 F YP=0,35+Y;T " "
11.09 R
11.10 F YP=0,34+Y;T " "
11.11 R;C PLOTS THE NEW COMPONENT (TERM) ALONE

12.01 S Y1=0
12.03 F D=1,N;S Y1=Y1+[<1/(2*D-1)>*A*FSIN(<2*D-1>*T)]
12.06 I (Y1)12.08,12.10,12.10
12.08 F YP=0,35+Y1;T " "
12.09 R
12.10 F YP=0,34+Y1;T " "
12.11 R;C PLOTS THE SUM OF THE COMPONENTS (TERMS) AVAILABLE
```

```
E A
C-FOCAL, 8/68

Ø1.Ø2   T   "FOURIER SYNTHESIS OF A SQUARE WAVE"!
Ø1.Ø3   T   "RECURSIVE TO THE NUMBER OF TERMS SPECIFIED"!!
Ø1.Ø4   S   PI=3.14159; A "AMPLITUDE",A,"TERMS IN FOURIER SERIES",L,!
Ø1.Ø6   S   N=Ø;S Y1=Ø;A "PLOT EVERY [ ? ] DEGREES",DG,!
Ø1.Ø7   T   "NEW COMPONENT PLOTS *, SUMMARY WAVEFORM PLOTS O"!!!!!!
Ø1.Ø8   F   Q=1,L;S N=N+1;D 1.1Ø;D 1Ø.1
Ø1.Ø9   T   !!"VARY THE PARAMETERS AND I'LL PLOT ANOTHER"!!!!!!!!!!!!;Q
Ø1.1Ø   T   !!"WAVEFORM DISPLAY IF FOURIER SERIES TERMS",N,!;S Z=Ø

Ø2.Ø1   C, [  D2 ] WILL DISPLAY N TERMS WITH PARAMETERS OF RECORD
Ø2.Ø2   A   "GIVE N FOR THE SEPARATE DISPLAY OF N TERMS",N;D 1.1;D 2.Ø6
Ø2.Ø4   T   !!!!!!!!!!!!;G 2.Ø2
Ø2.Ø6   F   T=Ø,DG*PI/18Ø,2*PI;D 12;T "X",#;D 1Ø.14

1Ø.1Ø   F   T=Ø,DG*PI/18Ø,2*PI;D 11;T "*",#;D 12;T "O",#;D 1Ø.14
1Ø.14   S   Z=Z+1;T %3,Z,%2,Y1,!

11.Ø2   S   Y=(1/[ 2*N-1 ] )*A*FSIN(<2*N-1>*T)
11.Ø6   I   (Y)11.Ø8,11.1Ø, 11.1Ø
11.Ø8   F   YP=Ø,35+Y;T " "
11.Ø9   R
11.1Ø   F   YP=Ø,34+Y;T " "
11.11   R;C PLOTS THE NEW COMPONENT (TERM) ALONE

12.Ø1   S   Y1=Ø
12.Ø3   F   D=1,N;S Y1=Y;+[ <1/(2*D-1)>*A*FSIN(<2*D-1>*T) ]
12.Ø6   I   (Y1) 12.Ø8, 12.1Ø, 12.1Ø
12.Ø8   F   YP=O,35+Y1;T " "
12.Ø9   R
12.1Ø   F   YP=O,34+Y1;T " "
12.11   R;C PLOTS THE SUM OF THE COMPONENTS (TERMS) AVAILABLE
*
```

C-FOCAL, 8/68

```
Ø1.1Ø   A   ?LL,UL,IN?,!
Ø1.2Ø   T   "X          Y",!; F X=LL,IN,UL; DO 2
Ø1.3Ø   Q

Ø2.1Ø   S   Z=X/5
Ø2.2Ø   T   %4 X,"       "Z
Ø2.23   I   ([FABS<Z>]  -1) 2.25,2.24,2.25
Ø2.24   T   !;R
Ø2.25   I   (X) 2.5Ø,2.3Ø,2.34
Ø2.3Ø   F   Y=Ø,Z+3Ø; T "."
Ø2.31   T   "*"; F Y=Z+3Ø,5Ø; T ".";
Ø2.32   T   !;R
Ø2.34   F   Y=Ø,3Ø; T " "
Ø2.37   T   "."
Ø2.4Ø   F   Y=2,Z; T " "
Ø2.45   T   "*",!; R
Ø2.5Ø   F   Y=Ø,3Ø+Z; T " "
Ø2.6Ø   T   "*"
Ø2.7Ø   F   Y=FABS(32+Z),3Ø; T " "
Ø2.8Ø   T   ".",!;R
*
```

HALF-WAVE PLOT FOR FASTER LOOK AT
FOURIER SYNTHESIS OF A SQUARE WAVE
RECURSIVE TO THE NUMBER OF TERMS SPECIFIED

AMPLITUDE:35 TERMS IN FOURIER SERIES:3
PLOT EVERY [?] DEGREES:15
NEW COMPONENT PLOTS *, SUMMARY WAVEFORM PLOTS O

WAVEFORM DISPLAY IF FOURIER SERIES TERMS= 1

```
=  1=  Ø                                  Ø
=  2=  9                                    Ø
=  3=  18                                     Ø
=  4=  25                                       Ø
=  5=  3Ø                                         Ø
=  6=  34                                           Ø
=  7=  35                                            Ø
=  8=  34                                           Ø
=  9=  3Ø                                         Ø
= 10=  25                                       Ø
= 11=  18                                     Ø
= 12=  9                                    Ø
= 13=  Ø                                  Ø
```

WAVEFORM DISPLAY IF FOURIER SERIES TERMS= 2

```
=  1=  Ø                                  Ø
=  2=  17                                    *        0
=  3=  29                                       *              0
=  4=  33                                       *                    0
=  5=  3Ø                                    *                       0
=  6=  26                                 *                             0
=  7=  23                              *                                   0
=  8=  26                                 *                             0
=  9=  3Ø                                    *                          0
= 10=  33                                       *                          0
= 11=  29                                       *                       0
= 12=  17                                       *        0
= 13=  Ø                                  Ø
```

WAVEFORM DISPLAY IF FOURIER SERIES TERMS= 3

```
=  1=  Ø                                  Ø
=  2=  24                                       *                    0
=  3=  33                                    *                             0
=  4=  28                                 *                                   0
=  5=  24                              *                                   0
=  6=  27                                    *                          0
=  7=  3Ø                                       *                             0
=  8=  27                                    *                          0
=  9=  24                                 *                             0
= 10=  28                                    *                                   0
= 11=  33                                    *                                   0
= 12=  24                                       *                    0
= 13=  Ø                                  Ø
```

VARY THE PARAMETERS AND I'LL PLOT ANOTHER

D 2
GIVE N FOR THE SEPARATE DISPLAY OF N TERMS:5


```
WAVEFORM DISPLAY  IF  FOURIER SERIES TERMS=   5
=   1=   Ø                                   X
=   2=  32                                                  X
=   3=  26                                              X
=   4=  27                                               X
=   5=  29                                                X
=   6=  26                                            X
=   7=  29                                                 X
=   8=  26                                            X
=   9=  29                                                X
=  1Ø=  27                                               X
=  11=                                                 X
=  12=                                                        X
=  13=   Ø                                   X
```

GIVE N FOR THE SEPARATE DISPLAY OF N TERMS:1Ø
WAVEFORM DISPLAY IF FOURIER SERIES TERMS= 1Ø

```
=   1=   Ø                                   X
=   2=  26                                              X
=   3=  29                                                X
=   4=  29                                                X
=   5=  28                                               X
=   6=  27                                               X
=   7=  27                                              X
=   8=  27                                               X
=   9=  28                                               X
=  1Ø=  29                                                X
=  11=  29                                                X
=  12=  26                                             X
=  13=   Ø                                   X
```

GIVE N FOR THE SEPARATE DISPLAY OF N TERMS:NEXT.?11.2Ø @Ø2.Ø2
*

D 2
GIVE N FOR THE SEPARATE DISPLAY OF N TERMS:2Ø

WAVEFORM DISPLAY IF FOURIER SERIES TERMS= 2Ø

```
=  1=  Ø                    X
=  2=  29                                  X
=  3=  28                                 X
=  4=  27                                X
=  5=  28                                 X
=  6=  28                                 X
=  7=  27                                 X
=  8=  28                                 X
=  9=  28                                 X
=  1Ø=  27                               X
=  11=  28                                X
=  12=  29                                 X
=  13=  Ø                    X
```

GIVE N FOR THE SEPARATE DISPLAY OF N TERMS: 5Ø

WAVEFORM DISPLAY IF FOURIER SERIES TERMS= 5Ø

```
=  1=  Ø                    X
=  2=  27                                 X
=  3=  28                                 X
=  4=  28                                 X
=  5=  28                                 X
=  6=  27                                 X
=  7=  27                                 X
=  8=  27                                 X
=  9=  28                                 X
=  1Ø=  28                                X
=  11=  28                                X
=  12=  27                                X
=  13=  Ø                    X
```

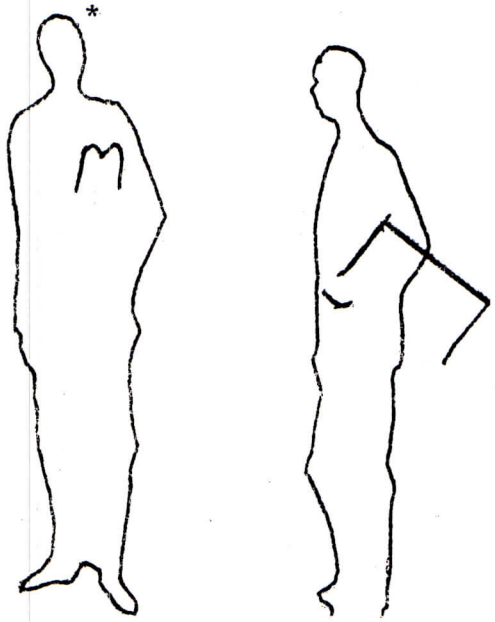
GIVE N FOR THE SEPARATE DISPLAY OF N TERMS:?Ø1.ØØ● Ø2.Ø2
*

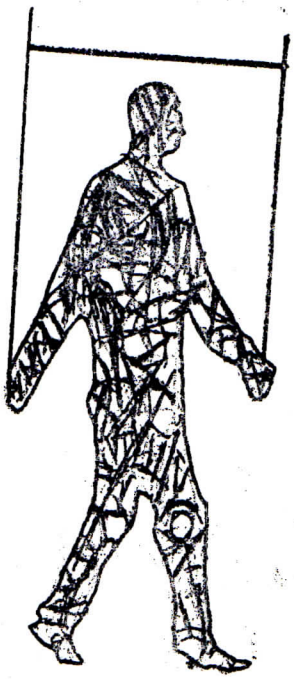
THIS IS A COPY OF THE RUN:
HALF-WAVE PLOT FOR FASTER LOOK AT
FOURIER SYNTHESIS OF A SQUARE WAVE AMPLITUDE*35 PLOT EVERY 1 DEGREE

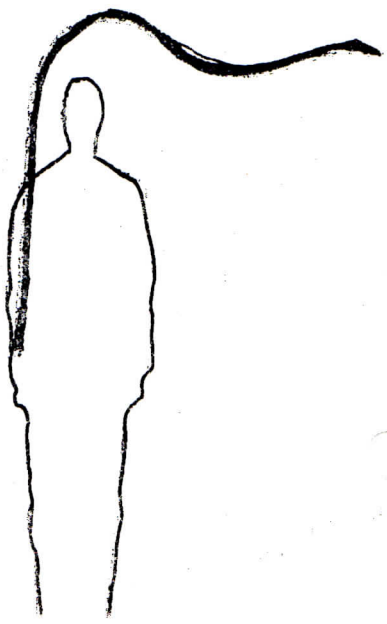
ONLY THE SUMMARY WAVEFORM IS SHOWN
D 2
GIVE N FOR THE SEPARATE DISPLAY OF N TERMS: 5Ø

WAVEFORM DISPLAY IF FOURIER SERIES TERMS= 5Ø

```
=   1=  Ø                                X
=   2=  26                             X
=   3=  32                                    X
=   4=  26                              X
=   5=  26                             X
=   6=  29                                 X
=   7=  29                                 X
=   8=  26                              X
=   9=  27                                X
=  1Ø=  29                                 X
=  11=  27                                X
=  12=  27                             X
=  13=  28                                X
=  14=  28                                 X
=  15=  27                             X
=  16=  27                                X
=  17=  28                                 X
=  18=  28                                X
=  19=  27                             X
=  2Ø=  28                                X
=  21=  28                                X
=  22=  27                                X
=  23=  27                                X
=  24=  28                                X
=  25=  28                                X
?Ø1.ØØ @ 12.Ø3
*
```







THIS IS A COPY OF THE RUN:
HALF-WAVE PLOT FOR FASTER LOOK AT
FOURIER SYNTHESIS OF A SQUARE WAVE AMPLITUDE*35 PLOT EVERY Ø.1 DEG.

(5A)

ONLY THE SUMMARY WAVEFORM IS SHOWN; COMPARE WITH 5Ø TERMS PLOTTED EVERY 1 DEGREE; LONG CALCULATION TIME MAKES THIS COPY DESIRABLE.

D 2

GIVE N FOR THE SEPARATE DISPLAY OF N TERMS:1ØØ

WAVEFORM DISPLAY IF FOURIER SERIES TERMS= Ø.1ØE+Ø3

```
=    1=  Ø                                   X
=    2=  6                                  X
=    3=  12                                  X
=    4=  17                                   X
=    5=  22                                    X
=    6=  26                                     X
=    7=  29                                      X
=    8=  31                                       X
=    9=  32                                        X
=   10=  33                                        X
=   11=  32                                        X
=   12=  31                                       X
=   13=  3Ø                                      X
=   14=  29                                      X
=   15=  28                                     X
=   16=  26                                     X
=   17=  26                                    X
=   18=  25                                   X
=   19=  25                                   X
=   2Ø=  25                                   X
=   21=  26                                    X
=   22=  26                                     X
=   23=  27                                     X
=   24=  28                                      X
=   25=  28                                       X
=   26=  29                                       X
=   27=  29                                        X
=   28=  29                                        X
=   29=  29                                        X
=   3Ø=  29                                       X
=   31=  29                                       X
=   32=  28                                      X
=   33=  27                                      X
=   34=  27                                     X
=   35=  27                                     X
=   36=  26                                     X
=   37=  26                                     X
=   38=  26                                     X
=   39=  27                                     X
=   4Ø=  27                                     X
```

```
=  41=  27                                                    X
=  42=  28                                                    X
=  43=  28                                                      X
=  44=  28                                                      X
?Ø1.ØØ @12.Ø3
*
```

5B

ONLY THE SUMMARY WAVEFORM IS SHOWN
THE EXCEPTIONALLY LONG CALCULATION TIME REQUIRED MAKES THIS COPY NECESSARY

(6A)

1ØØ PLOTTED POINTS REQUIRED 16 HOURS!

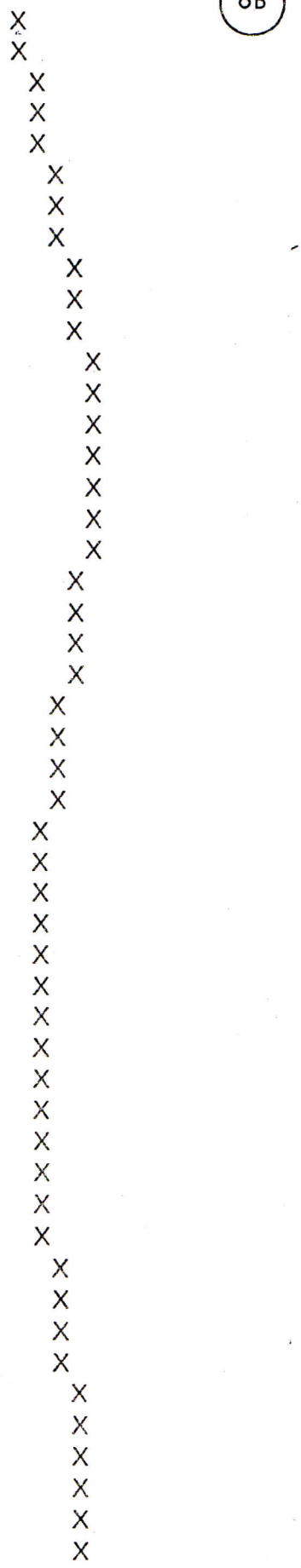
D 2
GIVE N FOR THE SEPARATE DISPLAY OF N TERMS: 5ØØ

WAVEFORM DISPLAY IF FOURIER SERIES TERMS= Ø.5ØE+Ø3

```
=   1=   Ø                                                  X
=   2=   3                                                   X
=   3=   6                                                    X
=   4=   9                                                     X
=   5=  12                                                      X
Ø   6=  15                                                       X
Ø   7=  17                                                        X
=   8=  2Ø                                                         X
=   9=  22                                                          X
=  1Ø=  24                                                           X
=  11=  26                                                            X
=  12=  28                                                             X
=  13=  29                                                              X
=  14=  3Ø                                                               X
=  15=  31                                                                X
=  16=  32                                                                 X
=  17=  32                                                                  X
=  18=  32                                                                  X
Ø  19=  33                                                                  X
Ø  2Ø=  32                                                                  X
Ø  21=  32                                                                  X
=  22=  32                                                                 X
=  23=  31                                                                X
=  24=  31                                                               X
=  25=  3Ø                                                              X
=  26=  3Ø                                                             X
=  27=  29                                                            X
Ø  28=  28                                                           X
=  29=  28                                                          X
=  3Ø=  27                                                         X
=  31=  26                                                        X
=  32=  26                                                       X
=  33=  26                                                       X
=  34=  25                                                       X
=  35=  25                                                      X
=  36=  25                                                      X
=  37=  25                                                      X
=  38=  25                                                      X
=  39=  25                                                      X
Ø  4Ø=  25                                                       X
```

6B

=	41=	26
=	42=	26
=	43=	26
=	44=	27
=	45=	27
=	46=	27
⊖	47=	28
⊖	48=	28
=	49=	28
=	5Ø=	29
=	51=	29
⊖	52=	29
=	53=	29
=	54=	29
=	55=	29
=	56=	29
=	57=	29
=	58=	29
⊖	59=	29
=	6Ø=	29
⊖	61=	29
⊖	62=	28
=	63=	28
=	64=	28
=	65=	27
=	66=	27
⊖	67=	27
=	68=	27
=	69=	27
=	7Ø=	26
=	71=	26
⊖	72=	26
=	73=	26
⊖	74=	26
=	75=	26
⊖	76=	26
=	77=	27
⊖	78=	27
=	79=	27
⊖	8Ø=	27
=	81=	27
=	82=	28
=	83=	28
⊖	84=	28
=	85=	28
=	86=	28
⊖	87=	28
⊖	88=	29
=	89=	29
⊖	9Ø=	29



(6C)

```
Ø  91=    29                                                    X
=  92=    29                                                    X
Ø  93=    29                                                    X
Ø  94=    29                                                    X
=  95=    28                                                    X
=  96=    28                                                    X
=  97=    28                                                    X
=  98=    28                                                  X
=  99=    28                                                  X
Ø 1ØØ=    28                                                  X
?Ø1.ØØ@ 12.Ø3
*C THESE LAST 1ØØ DATA REQUIRED 16 HOURS
*C OF COMPUTATION TIME TO SUM 5ØØ TERMS
*C FOR EACH DATUM.
*
```

```
?ØØ.ØØ
*W
C-FOCAL , 8/68

Ø1.Ø1  T    !!"HALF-WAVE PLOT FOR FASTER LOOK AT"!
Ø1.Ø2  T    "FOURIER SYNTHESIS OF A SQUARE WAVE"!
Ø1.Ø3  T    "RECURSIVE TO THE NUMBER OF TERMS SPECIFIED"!!
Ø1.Ø4  S    PI=3.14159; A "AMPLITUDE",A,"TERMS IN FOURIER SERIES",L,!
Ø1.Ø6  S    N=Ø;S Y1=Ø;A "PLOT EVERY [?] DEGREES",DG,!
Ø1.Ø7  T    "NEW COMPONENT PLOTS *, SUMMARY WAVEFORM PLOTS O"!!!!!!
Ø1.Ø8  F    Q=1,L;S N=N+1;D 1.1Ø;D 1Ø.1
Ø1.Ø9  T    !!"VARY THE PARAMETERS AND I'LL PLOT ANOTHER"!!!!!!!!!!!!;Q
Ø1.1Ø  T    !!"WAVEFORM DISPLAY IF FOURIER SERIES TERMS",N,!;S Z=Ø

Ø2.Ø1  C    [ D 2 ] WILL DISPLAY N TERMS WITH PARAMETERS OF RECORD
Ø2.Ø2  A    "GIVE N FOR THE SEPARATE DISPLAY OF N TERMS",N;D 1.1;D 2.Ø6
Ø2.Ø4  T    !!!!!!!!!!!!;G 2.Ø2
Ø2.Ø6  F    T=Ø,DG*PI/18Ø,PI;D 12;T "X",#;D 1Ø.14

1Ø.1Ø  F    T=Ø,DG*PI/18Ø,PI;D 11;T "*",#;D 12;T "0",#;0 1Ø.14
1Ø.14  S    Z=Z+1;T %3,Z,%2,Y1,!

11.Ø2  S    Y=(1/[2*N-1])*A*FSIN(<2*N-1>*T)
11.Ø6  I    (Y)11.Ø8,11.1Ø,11.1Ø
11.Ø8  F    YP=Ø,35+Y;T " "
11.Ø9  R
11.1Ø  F    YP=Ø,34+Y;T " "
11.11  R ;  C PLOTS THE NEW COMPONENT (TERMS) ALONE

12.Ø1  S    Y1=Ø
12.Ø3  F    D=1,N;S Y1=Y1+[<1/(2*D-1)>*A*FSIN(<2*D-1>*T)]
12.Ø6  I    (Y1)12.Ø8,12.1Ø,12.1Ø
12.Ø8  F    YP=0,35+Y1;T " "
12.Ø9  R
12.1Ø  F    YP=0,34+Y1;T " "
12.11  R ; C PLOTS THE SUM OF THE COMPONENTS (TERMS) AVAILABLE
*
```