DENVER WATER DEPARTMENT

SCIENTIFIC PROGRAM LIBRARY DOCUMENTATION

THIRD EDITION

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EDITED BY

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DATA PROCESSING

***** SCIENTIFIC PROGRAM LIBRARY DOCUMENTATION *****

INTRODUCTION

THIS DOCUMENT CONTAINS DOCUMENTATION ON THE PROGRAMS AND SUBPROGRAMS IN THE SCIENTIFIC PROGRAM LIBRARY AS WELL AS A LISTING OF UNIVAC'S PROGRAM LIBRARY.

THE GENERAL SCIENTIFIC PROGRAMS ARE DOCUMENTED IN SECTION ONE. THEY INCLUDE PROGRAMS TO:

- PERFORM STATISTICAL AND REGRESSION ANALYSES WITH PLOTS
- PERFORM MULTIPLE LINEAR REGRESSION ANALYSIS WITH PLOTS
- PERFORM CALCULATOR FUNCTIONS
- RE-NUMBER AND "TIDY" FORTRAN PROGRAMS
- FLOWCHART FORTRAN PROGRAMS
- PRINT A "DICTIONARY" OF A FORTRAN PROGRAM VARIABLES
- PRINT "RUN-ID" TYPE HEADINGS
- PRINT AND SAVE THE CURRENT DATE AND TIME

SEVERAL GENERAL FORTRAN SUBPROGRAMS ARE AVAILABLE IN ADDITION TO THOSE IN UNIVAC'S MATHEMATICAL, STATISTICAL, AND FORTRAN LIBRARIES. THESE GENERAL SUBPROGRAMS ARE LISTED AND DOCUMENTED IN SECTION TWO. THEY INCLUDE SUBPROGRAMS TO:

- PLOT SINGLE AND MULTIPLE FUNCTIONS
- PERFORM STATISTICAL AND REGRESSION ANALYSES
- PERFORM NUMERICAL TASKS
- PERFORM MISCELLANEOUS TASKS
- SORT INTEGER AND REAL DATA ARRAYS

THE LAST SECTION IS A LISTING OF ALL UNIVAC PROGRAMS AVAILABLE FOR USE ON THE DENVER WATER DEPARTMENT'S UNIVAC 1100/21. SOME OF THESE PROGRAMS HAVE BEEN OBTAINED AND ARE NOW RUNNING ON THE 1100/21. SCIENTIFIC PROGRAM LIBRARY PROGRAMS ARE ALSO INCLUDED IN THIS LIST.

THE DOCUMENTATION IS FOLLOWED BY APPENDIX A, AN ALPHABETICAL INDEX OF THE PROGRAMS SUBPROGRAMS IN THE SCIENTIFIC PROGRAM AND SUBPROGRAM LIBRARIES.

SOURCE CODE FOR ALL PROGRAMS AND SUBPROGRAMS ARE MAINTAINED BY THE SCIENTIFIC CONSULTANTS IN EDP. ANY CHANGES WILL BE MADE BY EDP. HOWEVER, SOURCE LISTINGS CAN BE MADE AVAILABLE TO ASSIST IN THE PROGRAMS AND SUBPROGRAMS.

PAGE

TABLE OF CONTENTS

PAGE

TABLE OF CONTENTS

1. SCIENTIFIC PROGRAM LIBRARY DOCUMENTATION

THE SCIENTIFIC PROGRAM LIBRARY CONTAINS SEVERAL GENERAL FORTRAN PROGRAMS WHICH ARE DOCUMENTED IN THE FOLLOWING PAGES. IT IS SUGGESTED THAT THE DOCUMENTATION FOR ANY ONE PROGRAM BE READ IN THIS ORDER:

PURPOSE
OUTPUT
INPUTS
STANDARD EXECUTION SEQUENCE
EXAMPLE
USER INSTRUCTIONS
ALL OTHER SECTIONS

IT IS ALSO SUGGESTED THAT THE USER SET UP A RUNSTREAM FOR USE ON HIS TERMINAL (@ADD) OR FOR BATCH RUNS (@START). THESE RUNSTREAMS CAN BE PATTERNED AFTER THE ONES IN SCUG*RUNSTRM OR THE EXAMPLES IN THE DOCUMENTATION.

1.1. @ANALYZE

PURPOSE-

THIS PROGRAM PERFORMS A STATISTICAL ANALYSIS AND CURVE FITTING (REGRESSION) ANALYSIS ON A SET OF (X,Y) DATA POINTS. IT ALSO PLOT THE DATA WITH OR WITHOUT THE CALCULATED REGRESSION CURVE POINTS. THE STATISTICAL ANALYSIS IS STANDARD, WHEREAS THE CURVE FITTING AND PLOTS ARE OPTIONAL.

THE REGRESSION ANALYSIS FITS THREE TYPES OF CURVES TO THE DATA. THESE CURVES ARE DEFINED BY AN EXPONENTIAL EQUATION, A GEOMETRIC EQUATION, AND A POLYNOMIAL EQUATION. (SEE SAMPLE OUTPUTS FOR THE EQUATIONS). THE USER MAY HAVE THE PROGRAM SELECT THE BEST FIT OF THESE THREE OR USE THE POLYNOMIAL EQUATION. IN EITHER CASE, THE RESULTS FOR EACH CURVE FITTING ARE PRINTED. IF THE POLYNOMIAL FIT IS NOT THE BEST, THE PROGRAM WILL COMPUTE AND PRINT THE REGRESSION POINTS, PLOT THE REGRESSION POINTS AND DATA, THEN LOOKS FOR NEW DATA.

IN THE POLYNOMIAL REGRESSION ANALYSIS, THE USER SPECIFIES THE LOWEST AND HIGHEST DEGREE POLYNOMIAL TO BE FIT. THE PROGRAM THEN FITS THE POLYNOMIALS IN ORDER OF ASCENDING DEGREE UNTIL THE INDEX OF DETERMINATION EQUALS 1.0 OR IS NOT IMPROVING. THE INDEX OF DETERMINATION, REGRESSION EQUATION COEFFICIENTS, STANDARD ERROR, AND (OPTIONALLY) THE CALCULATED REGRESSION POINTS ARE PRINTED FOR EACH FIT.

EXTRAPOLATION FORWARD OR BACKWARD IS ACCOMPLISHED WITH "HALF-STEP REGRESSION POINTS". THE REGRESSION EQUATION COEFFICIENTS ARE OUTPUT TO FILE 29.

HISTORY-

OBTAINED FROM OUTSIDE SOURCES
RE-WRITTEN TO ADD STATISTICS AND PLOTS BY K. JOHNSON MARCH 1976
ADDED EXPONENTIAL/GOEMETRIC REGRESSIONS AND PPLOTS, MAY, 1977.

OUTPUTS-

1) STATISTICAL ANALYSIS ON BOTH X AND Y COORDINATES- STANDARD
   - RANGE
   - MEAN
   - MEDIAN
   - MODE (FREQUENCY)
   - STANDARD ERROR (SQRT OF THE VARIANCE)

2) REGRESSION ANALYSIS FOR EACH DEGREE OF FIT- OPTIONAL
EQUATIONS-
POLYNOMIAL
GEOMETRIC
EXPONENTIAL
STANDARD OUTPUT-
INDEX OF DETERMINATION
COEFFICIENTS OF THE REGRESSION EQUATION
STANDARD ERROR OF ESTIMATE OF Y
PERCENT OF STANDARD ERROR OF Y
PERCENT OF MEAN OF Y
OPTIONAL OUTPUT (REGRESSION POINTS)-
CALCULATED Y VALUES USING REGRESSION EQUATION FOR EACH
X VALUE OR
HALF-STEP REGRESSION POINTS (USED TO SHOW REGRESSION
BETWEEN DATA POINTS AND/OR TO EXTRAPOLATE FORWARD
OR BACKWARD)

3) PLOT (Y VS X)- OPTIONAL
DATA AS POINTS OR BARS AND
REGRESSSION POINTS (IF COMPUTED) AS POINTS OVER DATA PLOT

4) REGRESSION COEFFICIENTS IN FILE 29- 18 DIGIT ACCURACY.

5) EXAMPLES- TO GET EXAMPLES OF ALL THE OPTIONS AVAILABLE TO PROGRAM ANALYZE, START A SPECIAL RUNSTREAM AS FOLLOWS:
@START SCUG*RUNSTRM.ANALYZE,,XXXYYY
WHERE XXXYYY = YOUR RUN-ID.

INPUTS-
TITLE
CONTROL PARAMETERS
DATA (X,Y) POINTS

RESTRICTIONS-
1) MAXIMUM DEGREE OF FIT = 11
2) MAXIMUM NUMBER OF DATA POINTS = 200
3) MAXIMUM HORIZONTAL PLOT SCALE = 115
4) LARGE X VALUES MAY CAUSE THE REGRESSION COEFFICIENTS TO EXCEED THE 18 DIGIT ACCURACY OF THEIR DOUBLE PRECISION STORAGE VARIABLES AT HIGHER ORDER FITS. THE IOD WILL DETERIORATE AND THE ANALYSIS WILL BE TERMINATED. SCALE THE X VALUES DOWN TO .LE. 100 TO INSURE AN ACCURATE REGRESSION ANALYSIS.
5) IT IS NOT RECOMMENDED THAT EXTRAPOLATION BE PERFORMED FOR MORE THAN 25% BEYOND THE RANGE OF X VALUES. ALSO, EXTRAPOLATION OF A HIGHER-ORDER FIT (> 1) MORE THAN 10-20% BEYOND THE X VALUE RANGE USUALLY LEADS TO A VERY LARGE NEGATIVE OR POSITIVE Y VALUE END-POINT.

ALGORITHMS-
SEE SUBROUTINES ANALYZ, EXPREG, GEOREG, POLREG, AND PPLOTS

```
INPUT FORMATS-
  1)  TITLE- 80 CHARACTERS STARTING IN SPACE 1
  2)  CONTROL PARAMETERS- FREE FORMAT (SEPARATE BY COMMAS OR BLANKS)
      M,IMD,ITRNS,IREG,N,NMX,IRPS,IHSRP,IPLT,IPS,IVB,IHB,IDO,ABS,ORD
           M      = NUMBER OF DATA (X,Y) POINTS.
           IMD    = 0 FOR (X,Y) POINTS, = 1 FOR Y POINTS (X(I)=I).
           ITRNS  = 0 = NO TRANSLATION, 1 = ADD X(1)=Y(1)=0.
           IREG   = 1 OR 2 TO PERFORM A REGRESSION ANALYSIS, OTHER-
                    WISE =0. (1=POLYNOMIAL ONLY, 2=BEST EQUATION).
            (WHEN IREG > 0, THE FOLLOWING ENTRIES ARE VALID.  IF
            IREG = 0, ENTER FIVE COMMAS).
             N    = BEGINNING DEGREE OF FIT
             NMX  = ENDING DEGREE OF FIT
             IRPS = 1 TO PRINT REGRESSION POINTS, OTHERWISE = 0.
             IHSRP= FOR HALF-STEP REGRESSION/EXTRAPOLATION POINTS,
                    THE NUMBER OF FULL STEPS DESIRED, OTHERWISE = 0.
                    (M .LE. ABS(IHRSP) .LE. M*1.5;  = POSITIVE FOR
                    FORWARD EXTRAPOLATION, = NEGATIVE FOR BACKWARD).
           IPLT   = 1 TO PLOT DATA (AND REGRESSION POINTS), OTHER-
                    WISE = 0.
            (WHEN IPLT > 0, THE FOLLOWING ENTRIES ARE VALID.  IF
            IPLT = 0, ENTER FIVE COMMAS).
             IPS  = ALTERNATE PLOT SIZE AS VVHHH
                    WHERE VV = VERTICAL AND HHH = HORIZONTAL SCALE
                    (VV AND HHH SHOULD BE DIVISIBLE BY 5).
                    OTHERWISE = 0 FOR STANDARD PLOT (50 X 115).
             IVB  = 1 TO PLOT WITH VERTICAL BARS.
             IHB  = 1 TO PLOT WITH HORIZONTAL BARS.
             IDO  = 1 TO SHIFT PLOT POINT ONE SPACE TO THE RIGHT
                    EACH TIME A SYMBOL WOULD BE DUPLICATED IN THE
                    SAME LOCATION, OTHERWISE =0.  MAKES FREQUENCY
                    DISTRIBUTIONS FOR SEVERAL SETS OF DATA.  MUST
                    NOT BE USED WITH VERTICAL OR HORIZONTAL BAR
                    PLOTS.
             ABS  = OPTIONAL ABSCISSA LABEL (.LE. 25 CHARACTERS;
                    MUST START WITH AN ALPHABETIC CHARACTER AND NOT
                    CONTAIN A COMMA).
             ORD  = OPTIONAL ORDINATE LABEL (.LE. 25 CHARACTERS)
  3)  DATA (X,Y) POINTS - FREE FORMAT (SEPARATE BY COMMAS OR BLANKS.
      DO NOT FOLLOW THE LAST DATA POINT ON A LINE WITH A COMMA).
           (X,Y) POINT DATA INPUT-
                X(1),Y(1),X(2),Y(2), . . . ,X(M),Y(M)
           Y POINT INPUT (X(I)=I)-
                Y(1),Y(2),Y(3), . . . ,Y(M)
```

USER INSTRUCTIONS-

1) PREPARE INPUTS ACCORDING TO THE INPUT FORMATS SECTION.
2) EXECUTE THE PROGRAM AS FOLLOWS:
   @ANALYZE
3) FOLLOW WITH AS MANY SETS OF INPUTS AS DESIRED.
4) FOLLOW THE LAST SET OF INPUTS WITH ANY JCL COMMAND.

STANDARD EXECUTION SEQUENCE-

```
@ANALYZE
TITLE
#PTS,0,0,1,1,3,1,#PTS,1,0,1,0,0
@ADD,PE FILENAME.DATANAME  (CONTAINING (X,Y) DATA)
```

EXAMPLE-

SEE THE NEXT FEW PAGES FOR AN OUTPUT CORRESPONDING TO THE 'STANDARD EXECUTION SEQUENCE'.

NOTE: '>' DENOTES AN INPUT; NORMALLY DOES NOT APPEAR ON PRINTED OUTPUT.

SUBPROGRAMS USED-

BSRTRR ANALYZ BSRTIR CENTER EXPREG POLREG(PNXTFT)
PEVALS ERRIOD PPLOTS

```
>@ANALYZE
>A N A L Y Z E      E X A M P L E
>10,0,0,1,1,3,1,10,1,0,1,0,0
>1,56 1.5,61 3,76 4.5,90 6.5,111 7.5,124 9,147 10,165 12,145 15,133
 A N A L Y Z E      E X A M P L E

 S T A T I S T I C A L   A N A L Y S I S

 NUMBER OF POINTS =   10

 VAR        MIN            MAX            MEAN          MEDIAN        MODE-      FREQ     STD.ERR
  Y       56.000         165.00          110.80         117.50        56.000        1       36.348
  X       1.0000         15.000          7.0000         7.0000        1.0000        1       4.3704

 R E G R E S S I O N   A N A L Y S E S

 EXPONENTIAL REGRESSION      Y = A(0)*A(1)**X

       INDEX OF DETERMINATION =          .53755

       TERM                        COEFFICIENT

         0               62.29967  ( .6229967390+002)
         1                1.07620  ( .1076199033+001)

 GEOMETRIC REGRESSION      Y = A(0)*X**A(1)

       INDEX OF DETERMINATION =          .82931

       TERM                        COEFFICIENT

         0               52.94858  ( .5294857783+002)
         1                 .40794  ( .4079443872+000)
```

A N A L Y Z E E X A M P L E FIT= 1 IOD= .73230

POLYNOMIAL REGRESSION Y = SUM OF (A(I)*(X**I)), I = 0,..DEGREE OF FIT

DEGREE OF FIT = 1 INDEX OF DETERMINATION = .73230

TERM	COEFFICIENT	
0	60.07749	(.6007748691*002)
1	7.24607	(.7246073298*001)

POLYNOMIAL REGRESSION POINTS

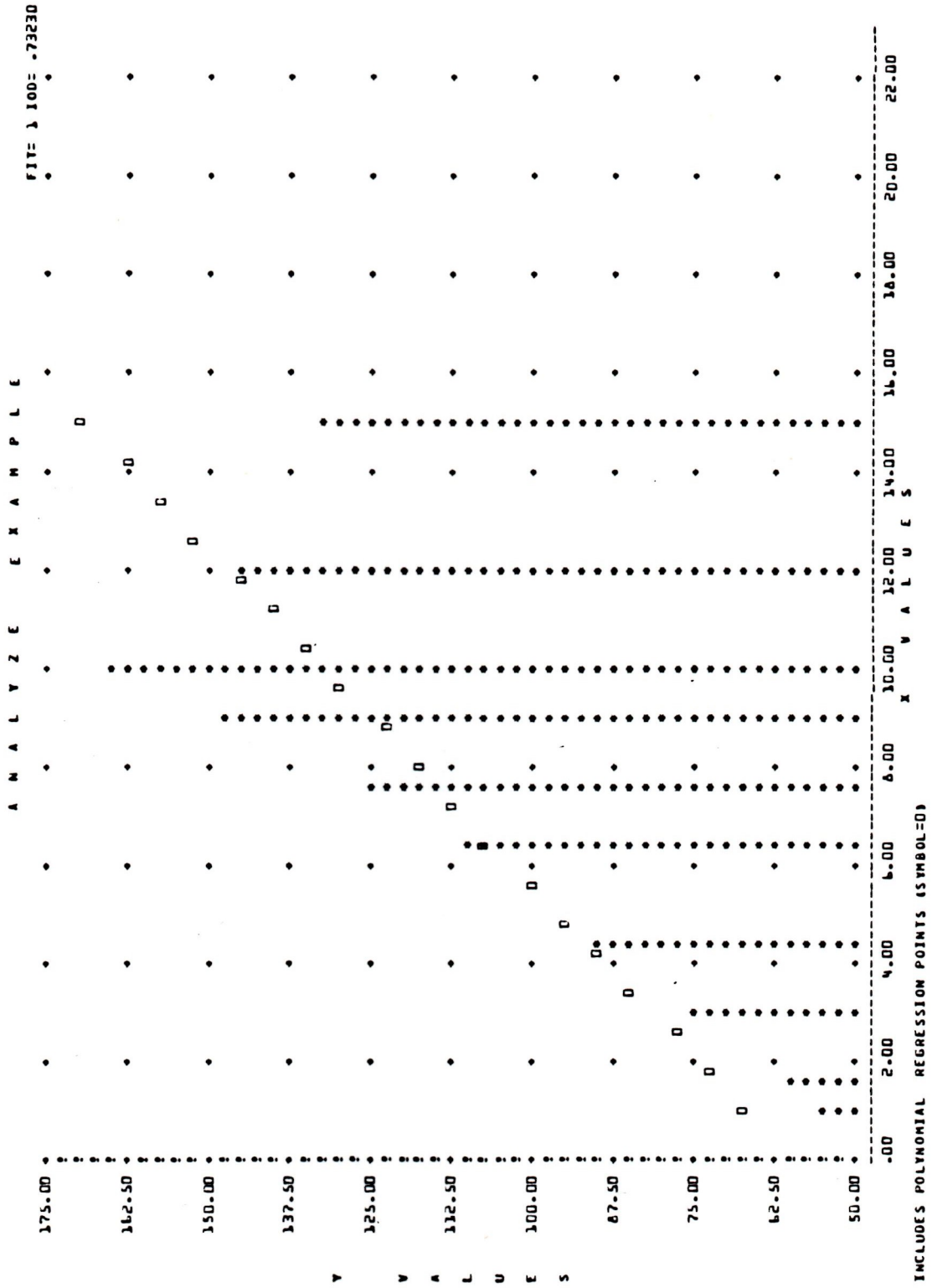
X-ACTUAL	Y-ACTUAL	Y-CALC.	RESIDUAL	PCT-DIFF
1.000	56.000	67.324	11.324	20.221
1.500	61.000	70.947	9.947	16.306
3.000	76.000	81.816	5.816	7.652
4.500	90.000	92.665	2.665	2.963
6.500	111.000	107.177	-3.823	-3.444
7.500	124.000	114.423	-9.577	-7.723
9.000	147.000	125.292	-21.708	-14.767
10.000	165.000	132.538	-32.462	-19.674
12.000	145.000	147.030	2.030	1.400
15.000	133.000	168.769	35.769	26.894

HALF-STEP POLYNOMIAL REGRESSION POINTS (X,Y)

1.00,	67.32	*	1.78,	72.96	*	2.56,	78.60	*	3.33,	84.23	*
4.89,	95.50	*	5.67,	101.14	*	6.44,	106.77	*	7.22,	112.41	*
8.78,	123.68	*	9.56,	129.32	*	10.33,	134.95	*	11.11,	140.59	*
12.67,	151.86	*	13.44,	157.50	*	14.22,	163.13	*	15.00,	168.77	*

4.11,	89.87	*			
8.00,	118.05	*			
11.89,	146.23	*			

STD ERROR OF ESTIMATE FOR Y = 19.94691
PERCENT OF STD ERROR OF Y = 54.9
PERCENT OF MEAN VALUE OF Y = 18.0


FIT= 1 100= .73230
ANALYZE EXAMPLE
Y VALUES
X VALUES
175.00
162.50
150.00
137.50
125.00
112.50
100.00
87.50
75.00
62.50
50.00
-.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
INCLUDES POLYNOMIAL REGRESSION POINTS (SYMBOL=D)

A N A L Y Z E E X A M P L E FIT= 2 IOD= .92041

POLYNOMIAL REGRESSION Y = SUM OF (A(I)*(X**I)), I = 0,..,DEGREE OF FIT

DEGREE OF FIT = 2 INDEX OF DETERMINATION = .92041

TERM	COEFFICIENT	
0	29.78471	(.297847070 9+002)
1	19.41229	(.194122888 2+002)
2	-.80574	(-.805737574 2+000)

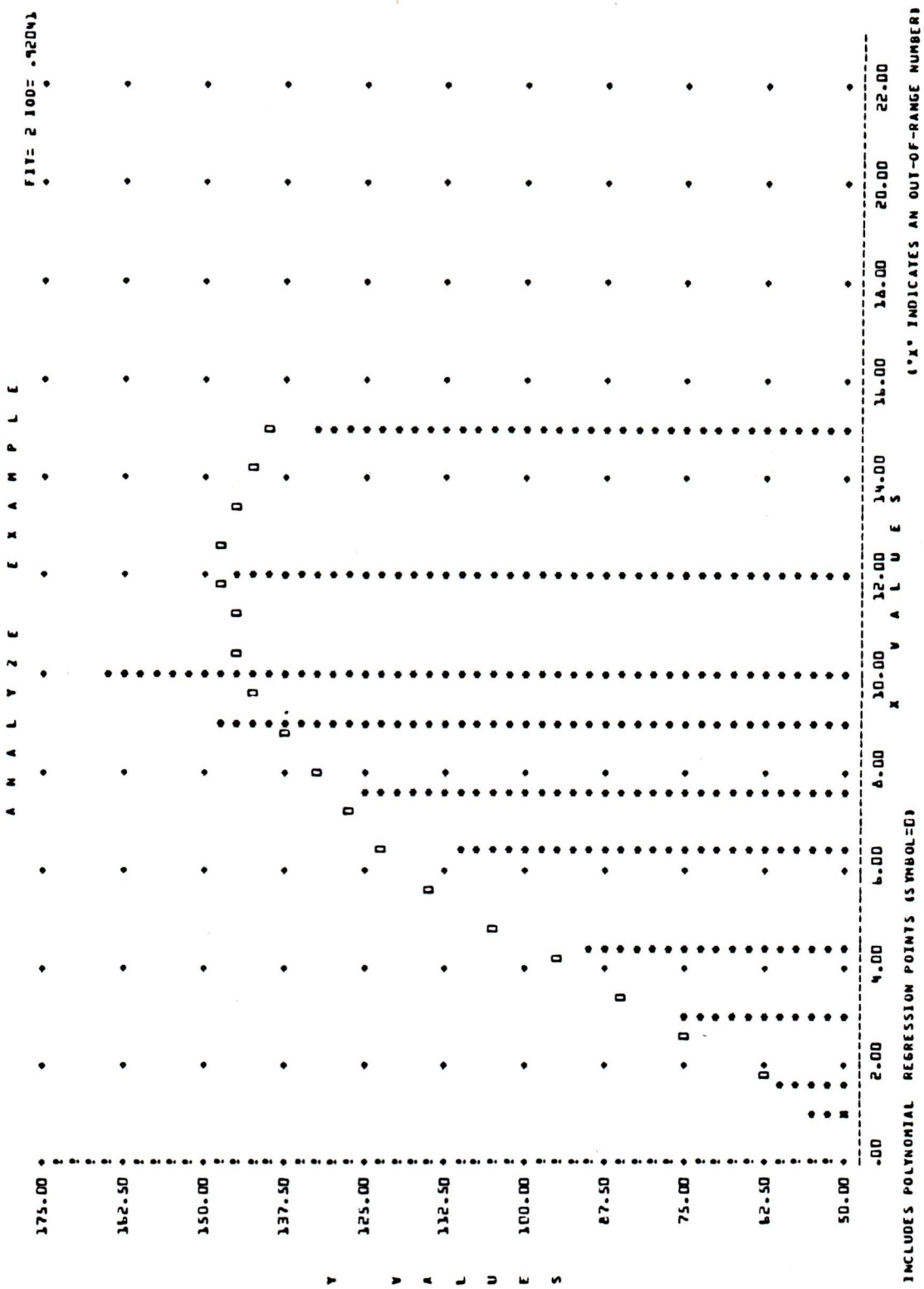
POLYNOMIAL REGRESSION POINTS

X-ACTUAL	Y-ACTUAL	Y-CALC.	RESIDUAL	PCT-DIFF
1.000	56.000	48.391	-7.609	-13.587
1.500	61.000	57.090	-3.910	-6.409
3.000	76.000	80.770	4.770	6.276
4.500	90.000	100.824	10.824	12.026
6.500	111.000	121.922	10.922	9.840
7.500	124.000	130.054	6.054	4.882
9.000	147.000	139.231	-7.769	-5.285
10.000	165.000	143.334	-21.666	-13.131
12.000	145.000	146.706	1.706	1.177
15.000	133.000	139.678	6.678	5.021

HALF-STEP POLYNOMIAL REGRESSION POINTS (X,Y)

1.00,	48.39	* 1.78,	61.75	* 2.56,	74.13	* 3.33,	85.54	* 4.11,	95.97	*	
4.89,	105.43	* 5.67,	113.91	* 6.44,	121.42	* 7.22,	127.96	* 8.00,	133.52	*	
8.78,	138.10	* 9.56,	141.71	* 10.33,	144.34	* 11.11,	146.00	* 11.89,	146.69	*	
12.67,	146.40	* 13.44,	145.13	* 14.22,	142.89	* 15.00,	139.68	*			

STD ERROR OF ESTIMATE FOR Y = 11.62710
PERCENT OF STD ERROR OF Y = 32.0
PERCENT OF MEAN VALUE OF Y = 10.5


FIT= 2 ORD= .920**2
ANALYZE EXAMPLE
Y VALUES
X VALUES
-.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
22.00
175.00
162.50
150.00
137.50
125.00
112.50
100.00
87.50
75.00
62.50
50.00
('*' INDICATES AN OUT-OF-RANGE NUMBER)
INCLUDES POLYNOMIAL REGRESSION POINTS (SYMBOL=0)

```
C    PROGRAM-  ANALYZE
C
C    VARIABLE DEFINITION-
C      M       = NUMBER OF POINTS
C      MAXNUM  = MAXIMUM NUMBER OF POINTS
C      N       = DEGREE OF FIT + 1
C      NMN     = MINIMUM DEGREE OF FIT
C      NMX     = MAXIMUM DEGREE OF FIT
C      MAXDEG  = MAXIMUM DEGREE OF FIT
C      MD      = MAXDEG
C      F29FLG  = FLAG INDICATING FILE 29 WAS WRITTEN REQUIRING AN EOF.
C      NM1     = DEGREE OF FIT
C      IOD     = INDEX OF DETERMINATION (REAL)
C      BIOD    = BEST INDEX OF DETERMINATION
C      SIOD    = IOD FROM PREVIOUS POLYNOMIAL FIT
C      COEFF   = COEFFICIENTS ARRAY
C      BCOEFF  = BEST COEFFICIENTS ARRAY
C      X       = X VALUES ARRAY
C      Y       = Y VALUES ARRAY
C      YCALC   = CALCULATED Y VALUES ARRAY
C      BYCALC  = BEST CALCULATED Y VALUES ARRAY
C      A,B,S   = WORKING ARRAYS
C      P,Q,G   = WORKING ARRAYS
C      YMEAN   = MEAN VALUE OF Y
C      YSTER   = STANDARD ERROR OF Y
C      VAR     = YSTER**2
C      YSTERE  = STANDARD ERROR OF ESTIMATE
C      ERVAR   = YSTERE**2
C      TITLE   = HEADING
C      TEMP    = TOP THREE MODES
C      IFREQ   = FREQUENCY OF THE TOP THREE MODES
C      NO      = ARRAY CONTAINING THE NUMBER OF DATA POINTS (NO(1))
C                AND THE NUMBER OF REGRESSION POINTS (NO(2)) FOR
C                PLOTTING
C      MARK    = ARRAY CONTAINING THE PLOT SYMBOLS FOR DATA POINTS
C                (MARK(1)) AND REGRESSION POINTS (MARK(2))
C      ICOUNT  = NUMBER OF POINTS IN THE PLOT ARRAYS (X & Y)
C      EQTYPE  = EQUATION TYPE ARRAY
C      PASS    = PLOT PASS FLAG (INITITAL=.FALSE., SUBSEQUENT=.TRUE.)
C      IBEQ    = BEST FIT EQUATION FLAG (1=POLYNOMIAL, 2=GEOMETRIC,
C                3=EXPONENTIAL)
C      ABSORD  = ABSCISSA AND ORDINATE INPUT ARRAY
C      ABS     = ABSCISSA LABEL (INTEGER, 25 WDS- 1 CHAR/WD)
C      ORD     = ORDINATE LABEL ARRAY (INTEGER, 25 WDS- 1 CHAR/WD)
C      OORFLG  = OUT-OF-RANGE (OOR) FLAG FROM SUBROUTINE PPLOTS
C                (NO OOR = 0, AT LEAST ONE OOR = THE OOR SYMBOL)
C      IRCMP   = 0 FOR NO PLOT MAX/MIN RECOMPUTATION, = 1 FOR RECOMP.
C      PSYM    = PLOT SYMBOL FOR VERTICAL BARS
C      PPSYM   = PLOT SYMBOL FOR POINTS AND HORIZONTAL BARS
C      SEE INPUT FORMATS FOR CONTROL PARAMETER DEFINITIONS.
C
       PARAMETER MAXDEG=11, MAXNUM=200, MXP1=MAXDEG+1, MXP4=MAXDEG+4
       PARAMETER MXN3=MAXNUM*3, MXNP1=MAXNUM+1, MXN302=MXN3/2
       REAL IOD
       LOGICAL F29FLG,PASS
```

First Page Only