NASA TECHNICAL MEMORANDUM

NASA TM X-1260

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PROGRAM FOR CALCULATION OF NEUTRON AGES FROM EXPERIMENTAL ACTIVATION DATA

by Thor T. Semler

Lewis Research Center

Cleveland, Ohio

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • JULY 1966

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SUMMARY

A program for the computation of neutron ages from experimental activation data is described. The quadrature schemes and error analyses are detailed along with some curve-fitting techniques. A "best-fit" derived from statistical decision theory is described.

INTRODUCTION

One important parameter found in the critical equation (eq. (1)) of age-diffusion theory is the neutron age τ (ref. 1):

$$\frac{Ke^{-B^2\tau}}{1 + B^2\mathscr{L}^2} = 1 \tag{1}$$

where K is the multiplication factor, B^2 the buckling, and $\mathscr{L}$ the diffusion length. The neutron age τ is related to the mean-square distance traveled by a neutron from its point of generation to its point of thermalization (ref. 1)

$$\tau = \frac{\overline{r^2}(E_i, E)}{6} \tag{2}$$

where E_i is the initial energy of the neutron and E is some lower energy generally in the thermal region.

Inasmuch as the value of $\overline{r^2}$ is impossible to measure directly, the saturated activity $A_s(R)$, which is directly proportional to the neutron flux distribution $\varphi(E, R)$ is measured by foil activation methods. The value of $\overline{r^2}$ may then be obtained by familiar averaging techniques; that is,

$$\overline{r^2} = \frac{\int_0^{\infty} R^4 A_s(R) dR}{\int_0^{\infty} R^2 A_s(R) dR} \tag{3}$$

and the neutron age may be obtained from equation (2).

The aforementioned set of integrations or averaging process, when done by hand, results in a neutron age subject to errors introduced by the individual calculating this age. In fact, the error introduced by hand quadrature might be as large as several square centimeters. Another problem associated with hand calculation is the assessment of the error in the age, that is, the sum of the experimental and calculational errors.

The ELLI code has been written to reduce the time necessary to calculate a neutron age and to provide a definite schema of procedural choices. It thus allows convenient comparison of several fitting and error analysis procedures.

In the analysis, the problem is defined, the numerical methods used are explained, and various approaches to the error assessment are presented.

SYMBOLS

$A_s(R)$	saturated activity, counts/min
B^2	buckling, cm^{-2}
$\|\|C_{rs}\|\|$	cofactor array of $\|\|c_{rs}\|\|$
$\|\|c_{rs}\|\|$	coefficient array of normal equations of weighted least-squares curve fit
D	determinant of array $\|\|c_{rs}\|\|$ (see eq. (27))
D_δ	breakpoint between region I and exponential region (fig. 1), cm
E	lower energy of neutron, eV
E_i	initial energy of neutron, eV
$F_{(\nu_1, \nu_2)}$	F test ratio
g	polynomial order
h	panel width of trapezoidal integration, cm

$\bar{h}$	average panel width, cm
K	multiplication factor
k	order of approximating polynomial
L	sum of ΔR_i (see eq. (20)), cm
M	evaluated by equation (21)
N+1	number of tabular values
n	degree of polynomial
P	proportionality constant
q(R, E)	slowing down density, neutrons/$cm^3 \cdot$ sec
R	distance from source, cm
R_δ	R_i corresponding to minimum value of D_i
$\overline{r^2}$	mean-square distance traveled by a neutron, cm^2
s^2	estimate of σ^2
W(R)	weighting function of $\tilde{y}(R)$
$\tilde{y}_i(R_i)$	i^{th} value of approximating polynomial
δ	index number of breakpoint
$\eta(R_i)$	residual of R_i
ξ	error estimate
$\Sigma_{In}(E)$	macroscopic absorption cross section of indium, cm^{-1}
σ^2	variance of curve fit
τ	neutron age, cm^2
$\varphi(E, R)$	neutron flux distribution, neutrons/cm^2

PROBLEM ANALYSIS

The Fermi age is related to the second moment of the slowing down density q(R, E) by equation (2). Experimentally, however, the flux age is measured by finding the spacial distribution of neutrons at a specific energy. For example, the activity, if saturation is assumed, of a cadmium-covered indium foil at a distance R from the source is

$$A_s(R) = P \int_{E_{Cd\ cutoff}}^{E_i} \Sigma_{In}(E)\varphi(E, R)dE \tag{4}$$

Since the value of the activation of the indium foil is nearly zero at all energies except that of the indium resonance, 1.44 electron volts, the flux age for the indium resonance neutrons, can be expressed as

$$\tau(E_i, E_{1.44eV}) = \frac{\overline{r^2}(E_i, E_{1.44eV})}{6} = \frac{1}{6}\left[\frac{\int_0^\infty R^4 A_s(R)dR}{\int_0^\infty R^2 A_s(R)dR}\right] \tag{5}$$

in spherical coordinates. This equation is then evaluated by the ELLI code. The methods by which these integrals are evaluated are outlined in the Numerical Analysis section. The calculation of the errors associated with these methods is shown in the Error Analysis section.

Numerical Analysis

For the purpose of integration, the experimentally determined activation times distance squared curve shown in figure 1 is separated into two portions. The shape of curve I has not been analytically determined, whereas curve II is assumed to be exponential (ref. 2). The breakpoint or division between curves I and II may be determined by the program or the experimenter. If the program option is selected, the derivatives of $A_s(R)R^2$ with respect to R are calculated by a difference method:

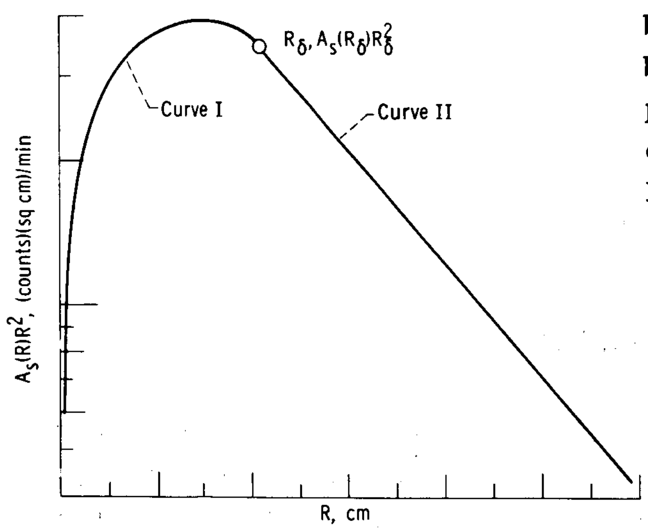

Figure 1. - Representative curve of distance squared times saturated activity against distance, with division point shown.

$$\frac{d\left[A_s(R)R^2\right]}{dR} = D_i\left[A_s(R)R^2\right]$$

$$\approx \frac{A_s(R_{i+1})R_{i+1}^2 - A_s(R_i)R_i^2}{R_{i+1} - R_i} \tag{6}$$

The value of R_i corresponding to the minimum value of the differences, that is, the largest negative value of D_i, is chosen as the breakpoint between curve I and the exponential region. If this specific value R_δ is not suitable, the breakpoint value can be chosen by the experimenter as in option 4 (see appendix).

Curve I is then integrated in any of several fashions that are left as options in the code. The first option available for the integration of curve I is the trapezoidal integration. This option should be used if many finely spaced points are to the left of the division point R_δ. The symbolic rule used for integration is

$$\int_0^{R_\delta} A_s(R)R^2\,dR \approx \sum_{i=1}^{i=\delta} \left[A_s(R_i)R_i^2 + A_s(R_{i-1})R_{i-1}^2\right]\left(\frac{R_i - R_{i-1}}{2}\right) \tag{7}$$

$$\int_0^{R_\delta} A_s(R)R^4\,dR \approx \sum_{i=1}^{i=\delta} \left[A_s(R_i)R_i^4 + A_s(R_{i-1})R_{i-1}^4\right]\left(\frac{R_i - R_{i-1}}{2}\right) \tag{8}$$

The contributions to the integrals are printed out, point by point, for this option. Sample computer output and a listing of the program are shown in the appendix.

The second option available is a least-squares polynomial curve fitted to the data. This option also allows the specification of the significance of the fit; that is, a certain confidence level for the polynomial fit may be inserted as program input. The program first attempts a quadratic fit to the curve I data, and then, if the confidence level criterion is not fulfilled, the program uses a cubic fit. This process is repeated, with the degree of the polynomial raised after each step, until the significance criterion is satisfied or until one of two other terminating conditions is found to exist. The two other terminating conditions are when (1) a tenth-degree polynomial is reached or when (2) the degree of the polynomial reaches one less than the number of points to be fitted. When either terminating condition is obtained, the appropriate action is taken. If condition (1) exists, the tenth-degree polynomial is integrated analytically; if condition (2) exists, the $(n-1)^{th}$ polynomial is likewise integrated. The test of significance is computed by a method following that of reference 3. First s^2, the estimate of the variance for the curve fit σ^2, is computed:

$$\sigma^2 \approx s^2 = \frac{\sum_{i=1}^{i=\delta} \left[A_s(R_i)R_i^2 - y_i\right]^2}{n - k - 1} \tag{9}$$

If the estimate of the variance computed for the g^{th} order polynomial by σ_g^2 is denoted, then the test for significance at the p^{th} confidence level, or probability of rejection, is found to be

$$\frac{(n - g)\delta_{g-1}^2 - (n - g - 1)\sigma_g^2}{\sigma_g^2} \geq F_{(1, n-g-1), 1-p} \tag{10}$$

where $F_{(\nu_1, \nu_2)}$ is the "well-known" F ratio of statistical analysis. If the change in variance is not significant at the specified level, the g^{th} polynomial is accepted and integrated by analytic means over the range from zero to R_δ. That is, if the probability level chosen is 0.500 and the probability that a cubic fit is better than a parabolic is only 0.400, the parabolic is accepted and integrated analytically.

The third option available is an averaged parabolic fit similar to that of reference 4. This option fits one parabola to the first three and another to the last three of four successive points. The coefficients thus generated are averaged and the curve is integrated in the overlapping region as shown in figure 2. In this option, the integration is done in small portions; for example, in figure 2 the integration would be from R_2 to R_3:

$$\int_{R_2}^{R_3} A_s(R)R^2\, dR = \int_{R_2}^{R_3} \left(\frac{a_0 + b_0}{2} + \frac{a_1 + b_1}{2} R + \frac{a_2 + b_2}{2} R^2\right) dR$$

$$= \left(\frac{a_0 + b_0}{2}\right)(R_3 - R_2) + \left(\frac{a_1 + b_1}{4}\right)\left(R_3^2 - R_2^2\right) + \left(\frac{a_2 + b_2}{6}\right)\left(R_3^3 - R_2^3\right) \tag{11}$$

This option produces a considerably better approximation to the integral than with the trapezoidal option inasmuch as curvature is allowed between points.

The exponential region of the curve, curve II, is fitted by a weighted least-squares exponential approximation. The $A_s(R_i)R_i^2$ values are transformed logarithmically by

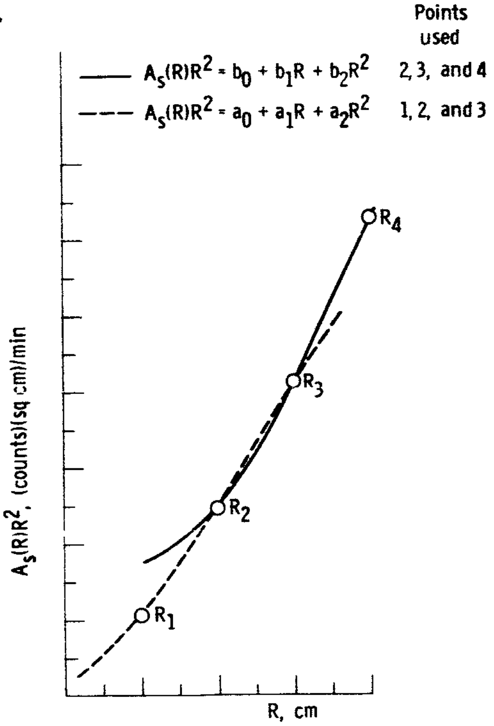

Figure 2. - Illustration of option 3 fit.

and

$$\left.\begin{aligned} y_i &= \ln\left[A_s(R_i)R_i^2\right] \\ x_i &= R_i \end{aligned}\right\} \tag{12}$$

Normalized weights are assigned proportional to the inverse of the square of the standard deviation or variance as determined by the counting statistics of a data point. Then a weighted least-squares linear fit is made to obtain the coefficients a_0 and a_1, such that

$$y_i \approx \tilde{y}_i = a_1x_i + a_0 \tag{13}$$

and subject to the condition that the weighted sum of the residuals squared S is minimized:

$$S = \sum_{i=\delta_p}^{N} W_i(\eta_i)^2 \equiv \sum_{i=\delta_p}^{N} W_i(y_i - \tilde{y}_i)^2 \tag{14}$$

Finally, the variables a_0 and a_1 are transformed back from the semilogarithmic coordinates by the transformation

$$\left.\begin{aligned} \alpha &= e^{a_0} \\ \beta &= a_1 \end{aligned}\right\} \tag{15}$$

The approximation

$$A_s(R_i)R_i^2 \approx \alpha e^{\beta R_i} \tag{16}$$

of curve II is integrated analytically from R_δ to ∞. The contribution to the integrals α and β appear in the output from the program. Option 4 allows the value of δ to be specified as part of the program input.

Error Analysis

The remaining options of the ELLI code provide for error estimation of the various integration options.

The error estimate ξ_1 of a trapezoidal integration is given by (ref. 5)

$$\xi_1 = -\frac{h^2}{12}\left\{\frac{d}{dR}\left[A_s(R_\delta)R_\delta^2\right]\right\} \tag{17}$$

where h is the panel width of the trapezoidal integration. Option 5 of ELLI uses $\bar{h}$, the average panel width, instead of h and the derivatives of a parabolic fit to the data in the range $(0, R_\delta)$ for the value of $d/dR\left[A_s(R_\delta)R_\delta^2\right]$. The fractional errors θ_1 and θ_2 of the two integrals (eqs. (7) and (8)) are then combined over the range $(0, R_\delta)$ while independence by the relation $\theta = \sqrt{\theta_1^2 + \theta_2^2}$ is assumed. This allows a fractional error to be assigned to the integration of curve I by the trapezoidal rule.

Option 6 assigns an error to the integration of option 2, which is an integration of a g^{th} degree polynomial fit. The error bound may be expressed as (ref. 6)

$$|\xi_2| \leq \frac{ML^{g+1}}{2(g+1)!}\int_0^{R_\delta} W(R)dR \tag{18}$$

where

$$\left.\begin{aligned} M &\geq \left|\frac{d^{(g+1)}}{dR^{(g+1)}}\tilde{y}(R)\right| \quad \text{in } (0, R_\delta) \\ L &= R_\delta - 0 \end{aligned}\right\} \tag{19}$$

and W(R) is the weighting function of $\tilde{y}(R)$. As the weighting function is relatively constant over curve I, a value of 1 shall be assigned to $W(R_i)$, and $\int_0^{R_\delta} W(R)dR$ shall be replaced by $\sum_{i=1}^{i=\delta} \Delta R_i = L$. Upon substitution, the following is obtained:

$$|\xi_2| \leq \frac{ML^{g+2}}{2^g(g+1)!} \tag{20}$$

In order to obtain an approximation of M, a (g + 2)th degree polynomial is fitted to the data, and the (g + 1)th derivative is taken and evaluated at R_δ:

$$M \approx \left| \frac{d^{(g+1)}}{dR^{(g+1)}} \tilde{y}(R_\delta) \right| \tag{21}$$

For both integrals ξ_2 is then computed, and a fractional error is assigned to the integration of curve I in the same manner as in option 5.

Option 7 is again an error assignment - in this case, to the option 3 integration of curve I. The error is given (ref. 5, p. 385) by

$$\xi_3 = \frac{h^4}{180} \left| \frac{d^3}{dR^3} y(R_\delta) \right| \tag{22}$$

because option 7 is similar to an unequally spaced Simpson's integration. Again, h is approximated by $\bar{h}$, $A_g(R)R^2$ is approximated over the interval $(0, R_\delta)$ by a fourth degree polynomial y(R), and the third derivative of this approximating polynomial is evaluated at R_δ. The fractional error associated with the two integrations over curve I is printed as in the previous options.

Finally, the error associated with the integration of the exponential portion, curve II, is calculated. This error calculation is described separately because it is computed in the same manner in options 5 to 7.

Reference 6 (pp. 261 to 269) shows that the error associated with the coefficients of a weighted polynomial approximation to tabular data may be represented by

$$\delta_{a_g} \approx \sqrt{\frac{C_{gg}}{D}} \sqrt{\frac{\Sigma W(R_i)\left[\eta(R_i)\right]^2}{N - n}} \tag{23}$$

For the case in question (see eq. (14)), the error formulae reduce to

$$\delta_{a_0} \approx \sqrt{\frac{\Sigma W(R_i) R_i^2}{D}}\, Q \tag{24}$$

$$\delta_{a_1} \approx \sqrt{\frac{\Sigma W(R_i)}{D}}\, Q \tag{25}$$

where

$$Q = \sqrt{\frac{\Sigma\left[W(R_i)\eta(R_i)^2\right]}{N - 1}}$$

$$D = \left[\Sigma W(R_i)\right]\left[\Sigma W(R_i)R_i^2\right] - \left[\Sigma W(R_i)R_i\right]^2 \tag{26}$$

and the summation runs from δ to the number of data points. Hence, if the transformation $\beta = a_1$ and $\alpha = e^{a_0}$ is used, to gain the exponential approximation, the errors transform as $\delta\beta = \delta a_1$ and $\delta\alpha = \alpha\delta a_0$. These errors are then propagated through the analytic integrations as standard errors.

CONCLUDING REMARKS

The ELLI code has been operative at Lewis for approximately 1 year. Experience gained by the operation of the program throughout this period has shown that all options are used about equally. The particular option chosen is to some degree dependent on the data and its quality. In general, the ages obtained through the use of the first three options vary by only a few tenths of a square centimeter. If the variance of these ages is much larger, more data are probably necessary.

Operation times for this code executed on the Lewis 7094-II computer are characteristically of the order of hundredths of a minute.

Lewis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, May 10, 1966.

APPENDIX - INPUT TO ELLI

CARD 1 FORMAT (A6)

bbbbbb in first six columns (if not blank a program description is output)

CARD 2 FORMAT (7I1)

Card columns 1-7	0 in column n if n^{th} option to be skipped; 1 if n^{th} option to be used. Options 5, 6, and 7 may be used only if the corresponding option 1, 2, or 3 has been used.

CARD 3 FORMAT (A6, 4X, A6, 4X, 8A6)

Card columns 1-6	ASbbbb If activations are to be read. ASR**2 If activations times R^2 are to be read.
Card columns 11-16	bbbbbb If data are in centimeters. INCHbb If data are in inches.
Card columns 21-68	Label for experiment.

CARD 4 FORMAT (I8, 12X, F10.3)

Card columns 1-8	Number of data points ≤ 100.
Card columns 21-30	Probability level of significance, $0.500 \leq p \leq 0.995$; needed only if option 2 is specified.

CARD 5 FORMAT (3F 15.4)

Card columns 1-15	R_i in inches or centimeters according to CARD 3.
Card columns 16-30	$A_s(R_i)$ or $A_s(R_i)R_i^2$ according to CARD 3.
Card columns 31-45	$\sigma[A_s(R_i)]$ or $\sigma\left[A_s(R_i)R_i^2\right]$ according to CARD 3.

LAST CARD FORMAT (I8)

If option 4 is chosen.

Card columns 1-8	δ is index of division point R_δ.

For more than one set of data, repeat starting with CARD 2 of INPUT TO ELLI.

```
      EQUIVALENCE(AZERO,ALPHA),(T(1),X(1)),(T(101),Y(1)),(T(201),STD(1))
     1,(T(401),DEV(1))
      DIMENSIONDEV(100),STD(100),T(100,5),X(100),XE(100),Y(100),LOGTR(10
     10),R2(100),DERL(100),C1(100),C2(100),C3(100),BLEK1(8),LABE(8),A1(2
     20),A2(20),A(20),ARB1(20),ARB2(20),Y2(100),XTEMP(100),TEMP(100),WEI
     3GH(100)
      REAL LOGTR
      REAL INTR2,INTR4,INTRP2,INTRP4
      INTEGER OPT1,OPT2,OPT3,OPT4,OPT5,OPT6,OPT7
      INTEGER EXPON,ZERO,DATAK,ASRSQ,AS,ORD,ORDN,ORDP1,ORDP2
      COMMON IVDZEO
 1000 READ(5,1010) HOW,BLEK,BLEK1

 1010 FORMAT(A6,4X,A6,4X,8A6)
 1011 FORMAT(7I1)
   10 WRITE (6,20)
   20 FORMAT(1H1,45X,36H AGE MEASUREMENT BY FOIL ACTIVATION. //)
 1012 READ(5,1011)OPT1,OPT2,OPT3,OPT4,OPT5,OPT6,OPT7

   22 DO 25 JB = 1,100
   23 DO 24 KB = 1,5
   24 T(JB,KB) = 0.0
      LOGTR(JB) = 0.0
      R2(JB) = 0.0
      DERL(JB) = 0.0
      C1(JB) = 0.0
      C2(JB) = 0.0
      C3(JB) = 0.0
      Y2(JB) = 0.0
      XTEMP(JB) = 0.0
      TEMP(JB) = 0.0
   25 WEIGH(JB) = 0.0
   26 DO 27 JK = 1,20
      A1(JK) = 0.0
      A2(JK) = 0.0
      A(JK)  = 0.0
      ARB1(JK) = 0.0
   27 ARB2(JK) = 0.0
   35 KLUG = 0
 1015 DATA BLAK,ASRSQ,AS/0606060606060,0216251545402,0216260606060/
 1016 DATA INCH/0314523306060/,ZERO/0/
 1020 IF(HOW-BLAK)1030,1050,1030
 1030 CALL HOWAGE
 1040 STOP
 1050 READ(5,1010) DATAK,LUM,LABE
 1060 IF(DATAK-ASRSQ)1070,50,1070
 1070 IF(DATAK-AS)1080,1110,1080
 1080 WRITE (6,1090)
 1090 FORMAT(20X,67H DATA FORMAT CARD INCORRECT OR MISPLACED.  SHOULD BE
```

```
     1 ASR**2 OR AS.   )
1100 STOP
1110 KLUG = 1
1120 GO TO 50
1130 DO 1140 IPER = 1,IDATA
1135 STD(IPER) = STD(IPER)*X(IPER)*X(IPER)
1140 Y(IPER) = X(IPER)*X(IPER)*Y(IPER)
1150 GO TO 90
  50 READ(5,60) IDATA,EPSILO,PE
  60 FORMAT(I8,2X,F10.3,F10.3)
  70 READ(5,80) ((T(IK,JUP),JUP=1,3),IK=1,IDATA)

  80 FORMAT(3F15.4)
9000 IF(OPT4)81,81,9010
9010 READ(5,9020) IPOL
9020 FORMAT(I8)
  81 IF(LUM-INCH)87,82,87
  82 DO 84 I = 1,100
  84 X(I) = X(I)*2.54
C    IF INCHES USED NO ASR**2 CARD
  85 IF(LUM-INCH.EQ.ZERO.AND.DATAK-ASRSQ.EQ.ZERO)GO TO 86
     GO TO 87
  86 WRITE(6,1160)
1160 FORMAT(18H ERROR CONDITION 4)
     STOP
  87 IF(KLUG) 1130,90,1130
  90 IMAX=1
9400 DO 9410 I = 1,IDATA
9410 Y2(I) = Y(I)*X(I)*X(I)
  91 IF(X(1))92,100,94
  92 WRITE(6,93)
  93 FORMAT(18H ERROR CONDITION 1)
     STOP
  94 IDATA = IDATA + 1
9030 IF(OPT4)9050,9050,9040
9040 IPOL = IPOL + 1
9050 IDM2 = IDATA - 2
     DO 95 I = ZERO,IDM2
     IP1 = I + 1
     IADAP = IDATA-IP1
     IADAS = IDATA -I
     X(IADAS) = X(IADAP)
     Y(IADAS) = Y(IADAP)
     Y2(IADAS) = Y2(IADAP)
  95 STD(IADAS) = STD(IADAP)
     Y2(1) = 0.0
     X(1) = 0.0
     Y(1) = 0.0
     STD(1) = STD(2)
 100 IF(OPT4)9060,9060,9070
9070 IZORK = IPOL
9080 GO TO 2000
9060 DO 110 IIP = 2,IDATA
 110 DERL(IIP) = (Y(IIP)-Y(IIP-1))/(X(IIP)-X(IIP-1))
 115 DERL(1) = 0.0
 120 MIN = 1
```

```
 130 DO 150 IZORK  =1,IDATA
 140 IF(DERL(MIN).GT.DERL(IZORK))MIN = IZORK
 150 CONTINUE
 160 IPOL = MIN
2000 IF(OPT1)2020,2010,2050
2010 GO TO 3000
2020 WRITE(6,2030)
2030 FORMAT(18H ERROR CONDITION 2)
2040 STOP
2050 OPT1 = OPT1-1
2051 WRITE (6,2060) LABE
2060 FORMAT(54X,9H OPTION 1,10X,8H LABEL =,8A6//)
2070 WRITE(6,2080)
2080 FORMAT(35X,2H 2/13X,2H R,17X,4H A R,11X,14H ST. DEVIATION,9X,12H P
    1ARTIAL SUM,10X,12H PARTIAL SUM/33X,2H S,34X,14H OF INTEGRAL 1,8X,
    214H OF INTEGRAL 2)
2090 SUM1 = 0.0
2100 SUM2 = 0.0
2110 SUM1 = (1.0/3.0)*X(2)*Y(2)
2120 SUM2 = (1.0/3.0)*Y(2)*X(2)**3
2130 WRITE(6,2140) X(1),Y(1),STD(1)
2140 FORMAT(7X,2PE15.7,4X,2PE15.7,6X,2PE15.7)
2150 WRITE(6,2210) X(2),Y(2),STD(2),SUM1,SUM2
2160 IFUD = IPOL - 1
2170 DO 2200 I = 3,IFUD

2180 SUM1 = SUM1 + 0.5*(Y(I)+Y(I-1))*(X(I)-X(I-1))
2190 SUM2 = SUM2 + 0.5*((Y(I)*X(I)**2)+(Y(I-1)*X(I-1)**2))*(X(I)-X(I-1)
    1)
2200 WRITE(6,2210)X(I),Y(I),STD(I),SUM1,SUM2
2210 FORMAT(7X,2PE15.7,4X,2PE15.7,6X,2PE15.7,6X,2PE15.7,8X,2PE15.7)
2220 SUM1 = SUM1 +0.5*(Y(IPOL)+Y(IPOL-1))*(X(IPOL)-X(IPOL-1))
2230 SUM2 = SUM2 + 0.5*((Y(IPOL)*X(IPOL)**2+Y(IPOL-1)*X(IPOL-1)**2)*(X(
    1IPOL)-X(IPOL-1)))
2240 WRITE(6,2250) X(IPOL),Y(IPOL),STD(IPOL),SUM1,SUM2
2242 TRA1 = SUM1
2244 TRA2 = SUM2
2250 FORMAT(3X,4H****,2PE15.7,4X,2PE15.7,6X,2PE15.7,6X,2PE15.7,8X,2PE15
    1.7,4H****///)
2260 ASSIGN 2280 TO ICOM
2270 GO TO 8000
2280 SUM1 = SUM1 + INTRP2
2290 SUM2 = SUM2 + INTRP4
2300 AGET = SUM2/(6.0*SUM1)
2310 WRITE (6,2320)
2320 FORMAT(43X,32H EXPONENTIAL REGION CALCULATIONS//35X,2H 2/13X,
    12H R,17X,4H A R,11X,14H ST. DEVIATION,8X,13HAPPROXIMATION,7X,
    216H PERCENTAGE DEV./33X,2H S)
2330 DO 2360 ILLK = IPOL,IDATA
2340 APR = ALPHA*EXP(BETA*X(ILLK))
2350 PDEV =((Y(ILLK)-APR)/STD(ILLK))*100.0
2360 WRITE (6,2370) X(ILLK),Y(ILLK),STD(ILLK),APR,PDEV
2370 FORMAT(7X,2PE15.7,4X,2PE15.7,6X,2PE15.7,6X,2PE15.7,7X,2PE15.7)
2380 EXLEN = 1.0/BETA
2390 WRITE(6,2400) AGET,AZERO,EXLEN,INTRP2,INTRP4
2400 FORMAT(42X, 38H AGE COMPUTED BY TRAPEZOIDAL OPTION IS/45X,2PE15.7,
```

```
     1,11HSQUARE CMS.///20X, 8H AZERO =, 2PE15.7,20X,20H RELAXATION LENG
     2TH =,2PE15.7//15X,31H INTEGRAL 1 OVER EXPONENTIAL IS,20X,
     331H INTEGRAL 2 OVER EXPONENTIAL IS/22X,2PE15.7,34X,2PE15.7)
2410 IF(OPT5)2420,2450,2460
2420 WRITE(6,2430)
2430 FORMAT(18H ERROR CONDITION 3)
2440 STOP
2450 GO TO 3000
2460 OPT5 = OPT5 - 1
2470 GO TO 5000
3000 IF(OPT2)3010,3040,3050
3010 WRITE(6,3020)
3020 FORMAT(18H ERROR CONDITION 7)
3030 STOP
3040 GO TO 4000
3050 OPT2 = OPT2 - 1
3060 WRITE(6,3070) LABE
3070 FORMAT(1H1,45X,36H AGE MEASUREMENT BY FOIL ACTIVATION.//34X, 9H OP
     1TION 2,10X,8H LABEL =,8A6//)
3080 WRITE(6,3090)
3090 FORMAT(40X,2H 2/20X,2H R,15X,4H A R,15X,19H STANDARD DEVIATION,
     114X,14H APPROXIMATION,7X,11H PERCENTAGE/38X,2H S,70X,10H DEVIATION
     2)
3100 ORD = 2
3110 ORDN = 3
3120 FORD = FLOAT(ORD)
3130 FORDN = FLOAT(ORDN)
3140 NN = IPOL
3150 FNN = FLOAT(IPOL)
3160 DO 3400 IBIS = 2,9
3170 CALL POYFZ(X,Y,IPOL,ORD,A1)
3180 CALL POYFZ(X,Y,IPOL,ORDN,A2)
3190 SIGMA1 = 0.0
3200 SIGMA2 = 0.0
3210 DO 3280 IKIS=1,NN
3220 YAP =A1(1)
3230 YORP = A2(1)
3240 DO 3260 ICIS = 1,10
3250 YAP = YAP + A1(ICIS+1)*X(IKIS)**ICIS
3260 YORP = YORP + A2(ICIS + 1)*X(IKIS)**ICIS
3270 SIGMA1 = SIGMA1 + (Y(IKIS) -YAP)**2
3280 SIGMA2 = SIGMA2 + (Y(IKIS)-YORP)**2
3290 SIGMA1 = SIGMA1/(FNN-FORD-1.0)
3300 SIGMA2 = SIGMA2/(FNN-FORDN-1.0)
3305 IF(SIGMA1.LE.0.0.OR.SIGMA2.LE.0.0)GO TO 3410
3310 NEST = NN -ORD
3320 IF((((FNN-FORDN)*SIGMA1-(FNN-FORDN-1.)*SIGMA2)/SIGMA2).LT.FTES(1,N
     1EST,PE)) GO TO 3410
3330 IF(NN-ORD-3)3340,3340,3370
3340 WRITE(6,3350)
3350 FORMAT(24H TERMINAL COND. 1 EXISTS)
3360 GO TO 3410
3370 ORD = ORD +1
3380 ORDN = ORDN + 1
3390 FORD = FLOAT(ORD)
3400 FORDN = FLOAT(ORDN)
```

```
3410 X1 = X(IPOL)
3420 XTEMP = 1.0
3430 XTEM2 = X1 * X1
3440 INTR2 = 0.0
3450 INTR4 = 0.0
3455 ORDP1 = ORD+ 1
3460 DO 3500 I = 1,ORDP1
3470 XTEMP = XTEMP*X1
3480 XTEM2 = XTEM2 * X1
3490 INTR2 = INTR2 + XTEMP*A1(I)/FLOAT(I)
3500 INTR4 = INTR4 + XTEM2 * A1(I)/FLOAT(I+2)
3510 APPRO = 0.0
3520 PDEV = 0.0
3530 DO 3580 I = 1,IPOL
3540 DO 3560 J = 1, ORDP1
3545 JM1 = J-1
3548 IF(JM1)3550,3550,3555
3550 XJTJM1 = 1.0
     GO TO 3560
3555 XJTJM1 = X(I)**JM1
3560 APPRO = APPRO + A1(J)*XJTJM1
3570 PDEV = ((Y(I) - APPRO)/STD(I))*100.0
3575 WRITE(6,3590)X(I),Y(I),STD(I),APPRO,PDEV
3580 APPRO = 0.0
3590 FORMAT(13X,E15.7,5X,E15.7,10X,E15.7,15X,E15.7,5X,2PE15.7)
3600 WRITE(6,3610)
3610 FORMAT(1H ,1H*,4X,1H*,4X,1H*,4X,1H*,4X,1H*,4X,1H*,4X,1H*,4X,1H*,
    14X,1H*,4X ,1H*,4X,1H*,4X,1H*,4X,1H*,4X,1H*,4X,1H*,4X,1H*,4X,1H*,
    24X,1H*,4X ,1H*,4X,1H*,4X,1H*,4X,1H*,4X,1H*,4X,1H*,4X,1H*,4X,1H*)
3614 WRITE(6,3615) SIGMA1,PE
3615 FORMAT(10X,17H SIGMA1 SQUARED =,E15.7,20X,24H LEVEL OF SIGNIFICANC
    1E =,E10.4)
3620 ASSIGN 3640 TO ICOM
3630 GO TO 8000
3640 WRITE(6,2320)
3650 HSU1 = INTR2 + INTRP2
3660 HSU2 = INTR4 + INTRP4
3670 HAGE = HSU2/(6.0*HSU1)
3680 DO 3710 ILLK=IPOL,IDATA
3690 APR = ALPHA*EXP(BETA*X(ILLK))
3700 PDEV =((Y(ILLK)-APR)/STD(ILLK))*100.0
3710 WRITE(6,2370) X(ILLK),Y(ILLK),STD(ILLK),APR,PDEV
3720 EXLEN = 1.0/BETA
3730 WRITE(6,3740) HAGE,AZERO,EXLEN,INTRP2,INTRP4,ORD
3740 FORMAT(42X,38H AGE COMPUTED BY POLYNOMIAL OPTION IS //45X,2PE15.7,
    1,11HSQUARE CMS.///20X, 8H AZERO =, 2PE15.7,20X,20H RELAXATION LENG
    2TH =, 2PE15.7//15X,31H INTEGRAL 1 OVER EXPONENTIAL IS,20X,
    331H INTEGRAL 2 OVER EXPONENTIAL IS/22X,2PE15.7,34X,2PE15.7/
    450X,21H DEGREE OF EQUATION =,I3)
3750 IF(OPT6)3760,3790,3800
3760 WRITE(6,3770)
3770 FORMAT(18H ERROR CONDITION 9)
3780 STOP
3790 GO TO 4000
3800 OPT6 = OPT6 - 1
3810 GO TO 6000
```

```
4000 IF(OPT3)4010,4040,4050
4010 WRITE(6,4020)
4020 FORMAT(18H ERROR CONDITION 5)
4030 STOP
4040 GO TO 1012
4050 OPT3 = OPT3 - 1
4060 WRITE(6,4070) LABE
4070 FORMAT(1H1,45X,36H AGE MEASUREMENT BY FOIL ACTIVATION.//34X, 9H OP
    1TION 3,10X,8H LABEL =,8A6//)
4080 WRITE(6,2080)
4090 XI = X(1)
4100 XT = X(2)
4110 XI2 = X(3)
4120 YI = Y(1)
4130 YI1 = Y(2)
4140 YI2 = Y(3)
4150 INTRP2 = 0.0
4160 INTRP4 = 0.0
4170 INTR2 = 0.0
4180 INTR4 = 0.0
4190 CALL PARA(XI,YI,XT,YI1,XI2,YI2,AP1,AP2,AP3)
4200 INTR2 = AP1*XT*XT*XT /3.0 + AP2*XT*XT/2.0 + AP3*XT
4210 INTR4 = AP1*XT**5/5.0 + AP2*XT**4/4.0 + AP3*XT**3/3.0
4220 WRITE(6,2140) X(1),Y(1),STD(1)
4230 WRITE(6,2210) X(2),Y(2),STD(2),INTR2,INTR4
4235 IFUD = IPOL - 1
4240 DO 4410 I = 3,IFUD
4250 XP = X(I-2)
4260 XT = X(I-1)
4270 XA = X(I)
4280 XAA = X(I+1)
4290 YP = Y(I-2)
4300 YT = Y(I-1)
4310 YA = Y(I)
4320 YAA = Y(I+1)
4330 CALL PARA(XP,YP,XT,YT,XA,YA,ABEF1,ABEF2,ABEF3)
4340 CALL PARA(XT,YT,XA,YA,XAA,YAA,AAFT1,AAFT2,AAFT3)
4350 INTRP2 = ((ABEF1+AAFT1)/6.0)*(XA**3-XT**3) + ((ABEF2+AAFT2)/4.0)
    1*(XA*XA-XT*XT)+((ABEF3+AAFT3)/2.0)*(XA-XT)
4360 INTRP4 = ((ABEF1+AAFT1)/10.0)*(XA**5-XT**5) + ((ABEF2+AAFT2)/8.0)*
    1(XA**4-XT**4) + ((ABEF3+AAFT3)/6.0)*(XA**3-XT**3)
4370 INTR2 = INTRP2 + INTR2
4380 INTR4 = INTRP4 + INTR4
4390 INTRP2 = 0.0
4400 INTRP4 = 0.0
4410 WRITE(6,2210) X(I),Y(I),STD(I),INTR2,INTR4
4420 XP = X(IPOL-2)
4430 XT = X(IPOL-1)
4440 XA = X(IPOL)
4450 XAA = X(IPOL+1)
4460 YP = Y(IPOL-2)
4470 YT = Y(IPOL-1)
4480 YA = Y(IPOL)
4490 YAA = Y(IPOL+1)
4500 CALL PARA(XP,YP,XT,YT,XA,YA,ABEF1,ABEF2,ABEF3)
4510 CALL PARA(XT,YT,XA,YA,XAA,YAA,AAFT1,AAFT2,AAFT3)
```

```
 4520 INTRP2 = ((ABEF1+AAFT1)/6.0)*(XA**3-XT**3) + ((ABEF2+AAFT2)/4.0)
     1*(XA*XA-XT*XT)+((ABEF3+AAFT3)/2.0)*(XA-XT)
 4530 INTRP4 = ((ABEF1+AAFT1)/10.0)*(XA**5-XT**5) + ((ABEF2+AAFT2)/8.0)*
     1(XA**4-XT**4) + ((ABEF3+AAFT3)/6.0)*(XA**3-XT**3)
 4540 INTR2 = INTRP2 + INTR2
 4550 INTR4 = INTRP4 + INTR4
 4560 INTRP2 = 0.0
 4570 INTRP4 = 0.0
 4580 WRITE (6,2250) X(IPOL),Y(IPOL),STD(IPOL),INTR2,INTR4
 4590 PARV1 = INTR2
 4600 PARV2 = INTR4
 4610 ASSIGN 4630 TO ICOM
 4620 GO TO 8000
 4630 INTR2 = INTR2 + INTRP2
 4640 INTR4 = INTR4 + INTRP4
 4650 AGEP = INTR4/(6.0*INTR2)
 4660 WRITE(6,2320)
 4670 DO 4700 ILLK = IPOL,IDATA
 4680 APR = ALPHA*EXP(BETA*X(ILLK))
 4690 PDEV =((Y(ILLK)-APR)/STD(ILLK))*100.0
 4700 WRITE (6,2370) X(ILLK),Y(ILLK),STD(ILLK),APR,PDEV
 4710 EXLEN = 1.0/BETA
 4720 WRITE(6,4730) AGEP,AZERO,EXLEN,INTRP2,INTRP4
 4730 FORMAT(43X,36H AGE COMPUTED BY PARABOLIC OPTION IS/ 45X,2PE15.7
     1,11HSQUARE CMS.///20X, 8H AZERO =, 2PE15.7,20X,20H RELAXATION LENG
     2TH =,2PE15.7//15X,31H INTEGRAL 1 OVER EXPONENTIAL IS,20X,
     331H INTEGRAL 2 OVER EXPONENTIAL IS/22X,2PE15.7,34X,2PE15.7)
 4740 IF(OPT7)4750,4780,4790
 4750 WRITE(6,4760)
 4760 FORMAT(18H ERROR CONDITION 6)
 4770 STOP
 4780 GO TO 1012
 4790 OPT7 = OPT7-1
 4800 GO TO 7000
 5000 FARD = 0.0
 5010 FLUP = 0.0
 5020 FLURG = 0.0
 5030 FARD = X(IPOL)/(FLOAT(IPOL-1))
 5040 FLUP = FARD*FARD/12.0
 5050 CALL POYFZ(X,Y,IPOL,2,A)
C       DIMENSION A(20)
 5060 FLURG = 2.0 * A(3) * X(IPOL) *FLUP
 5070 ZARD = 0.0
 5080 ZLURG = 0.0
 5090 ZARD = FLUP
 5100 CALL POYFZ(X,Y2,IPOL,2,A)
 5110 ZLURG = 2.0* A(3) * X(IPOL)*ZARD
 5120 ZUCH = FLURG/TRA1
 5130 ZOOH = ZLURG/TRA2
 5140 ERROR1 = SQRT(ZUCH*ZUCH+ZOOH*ZOOH)
 5150 ERRR = (1.0/6.0)*(1.0/SUM1)*SQRT((ZLURG)**2+(ERRE2)**2+((6.0*AGET)
     1**2)*((FLURG)**2+(INTRP2*ERREX)**2))/AGET
 5160 DELAGE = AGET*ERRR*0.5
 5170 WRITE(6,5180) ZUCH,ZOOH,ERROR1,DAZ,DBET,ERREX,ERRR2,ERRR  ,DELAGE
 5180 FORMAT(1H1,54X,9H OPTION 5///14X,31H FRACTIONAL ERROR IN INTEGRAL
     11, 28X,31H FRACTIONAL ERROR IN INTEGRAL 2/18X,23H OVER TRAPEZOIDAL
```

```
     2 RANGE,37X,23H OVER TRAPEZOIDAL RANGE/23X,E13.7,45X,E13.7/38X,
     340H FRACTIONAL ERROR IN CURVE I INTEGRATION/ 51X, E13.7///20X,
     417H ERROR IN AZERO =,E13.7,30X,16H ERROR IN BETA =,E13.7//14X,
     531H FRACTIONAL ERROR IN INTEGRAL 1,28X,31H FRACTIONAL ERROR IN INT
     6EGRAL 2/ 18X, 23H OVER EXPONENTIAL RANGE,37X, 23H OVER EXPONENTIAL
     7 RANGE/23X,E13.7,45X,E13.7//38X,42H FRACTIONAL ERROR IN THE TOTAL
     8INTEGRATION/56X,E13.7////30X,40H ERROR IN AGE IS EQUAL TO PLUS OR
     9MINUS ,2PE13.5,12H SQUARE CMS.)
5190 GO TO 3000
6000 KORD = ORD + 1
6010 CALL POYFZ(X,Y,IPOL,KORD,ARB1)
6020 WAP = ARB1(KORD+1)
6030 LORD = 1
6040 DO 6050 I = 1,ORD
6050 LORD = LORD*(KORD-I)
6060 FLORD = FLOAT(LORD)
6070 HEL = X(IPOL)/FLOAT(IPOL-1)
6080 ORDP2 = ORD+2
6090 ORDP1 = ORD + 1
6100 HEL = HEL**ORDP2
6110 ENY = 1.0
6120 DO 6130 I = 1,ORDP1
6130 ENY = ENY*(FLOAT(I))
6140 RERR = HEL*FLORD*X(IPOL)*WAP/((2.0**ORD)*ENY)
6150 FSU1 = RERR/INTR2
6160 RERR2 = RERR*X(IPOL)*X(IPOL)/FLOAT((KORD+1)*KORD)
6170 FSU2 = RERR2/INTR4
6180 ERFP1 = SQRT(FSU1*FSU1 + FSU2*FSU2)
6190 ERFPR = (1.0/6.0)*(1.0/HSU1)*SQRT((RERR2)**2+(ERRE2)**2+((6.0*HAGE
     1)**2)*((RERR)**2+(INTRP2*ERREX)**2))/HAGE
6200 DEHAGE = HAGE*0.5*ERFPR
6210 WRITE(6,6220)FSU1,FSU2,ERFP1,DAZ,DBET,ERREX,ERRR2,ERFPR,DEHAGE
6220 FORMAT(1H1,54X,9H OPTION 6///14X,31H FRACTIONAL ERROR IN INTEGRAL
     11,28X, 31H FRACTIONAL ERROR IN INTEGRAL 2/19X,22H OVER POLYNOMIAL
     2RANGE,35X,22H OVER POLYNOMIAL RANGE/                 23X,E13.7,45X,
     3E13.7/38X,40H FRACTIONAL ERROR IN CURVE I INTEGRATION/51X,E13.7///
     420X,17H ERROR IN AZERO =,E13.7,30X,16H ERROR IN BETA =,E13.7//14X,
     531H FRACTIONAL ERROR IN INTEGRAL 1,28X,31H FRACTIONAL ERROR IN INT
     6EGRAL 2/ 18X,23H OVER EXPONENTIAL RANGE,37X,23H OVER EXPONENTIAL R
     7ANGE/23X,E13.7,45X,E13.7//38X,42H FRACTIONAL ERROR IN THE TOTAL IN
     8TEGRATION/56X,E13.7////30X,40H ERROR IN AGE IS EQUAL TO PLUS OR MI
     9NUS ,2PE13.5,12H SQUARE CMS.)
6230 GO TO 4000
7000 BARD = 0.0
7010 BLURG = 0.0
7020 BARD = X(IPOL)/(FLOAT(IPOL-1))
7030 BLUP = BARD**4/180.0
7040 CALL POYFZ(X,Y,IPOL,4,A)
7050 BLURG = BLUP*24.0*A(5)*X(IPOL)
7060 CARD = 0.0
7070 CLURG = 0.0
7080 CARD = BLUP
7090 CALL POYFZ(X,Y2,IPOL,4,A)
7100 CLURG = 24.0*A(5)*CARD*X(IPOL)
7110 PUCH = BLURG/PARV1
7120 POOH = CLURG/PARV2
```

```
7130 ERROR3 = SQRT(PUCH*PUCH + POOH*POOH)
7140 ERRRP = (1.0/6.0)*(1.0/INTR2)*SQRT((CLURG)**2+(ERRE2)**2+((6.0*AGE
    1P)**2)*((BLURG)**2+(INTRP2*ERREX)**2))/AGEP
7150 DEAGEP = AGEP*ERRRP*0.50
7160 WRITE(6,7170)PUCH,POOH,ERROR3,DAZ,DBET,ERREX,ERRR2,ERRRP,DEAGEP
7170 FORMAT(1H1,54X,9H OPTION 7///14X,31H FRACTIONAL ERROR IN INTEGRAL
    11,28X, 31H FRACTIONAL ERROR IN INTEGRAL 2/15X,30H OVER SMOOTHED PA
    2RABOLIC RANGE,31X,30H OVER SMOOTHED PARABOLIC RANGE/23X,E13.7,45X,
    3E13.7/38X,40H FRACTIONAL ERROR IN CURVE I INTEGRATION/51X,E13.7///
    420X,17H ERROR IN AZERO =,E13.7,30X,16H ERROR IN BETA =,E13.7//14X,
    531H FRACTIONAL ERROR IN INTEGRAL 1,28X,31H FRACTIONAL ERROR IN INT
    6EGRAL 2/ 18X,23H OVER EXPONENTIAL RANGE,37X,23H OVER EXPONENTIAL R
    7ANGE/23X,E13.7,45X,E13.7//38X,42H FRACTIONAL ERROR IN THE TOTAL IN
    8TEGRATION/56X,E13.7////30X,40H ERROR IN AGE IS EQUAL TO PLUS OR MI
    9NUS ,2PE13.5,12H SQUARE CMS.)
7180 GO TO 1012
8000 AZERO = 0.0
8010 BETA = 0.0
8015 GLOCK = 0.0
8020 DO 8030 M = IPOL,IDATA
8025 WEIGH(M) = 1.0E+04/(STD(M)*STD(M))
8030 GLOCK = GLOCK + WEIGH(M)
8032 DO 8034 M = IPOL,IDATA
8034 WEIGH(M) = WEIGH(M)/GLOCK
8040 CALL WEXPFT(X,Y,WEIGH,IPOL,IDATA,AZERO,BETA,DAZ,DBET)
8045 B2 = X(IPOL)*X(IPOL)
8050 INTRP2=(-AZERO/BETA)*EXP(
    1BETA*X(IPOL))
8060 INTRP4=AZERO*(-B2*EXP(BETA*
    1X(IPOL))/BETA+(2.0*EXP(BETA*X(IPOL))/
    2BETA**3)*(BETA*X(IPOL)-1.0))
8070 ERREX = SQRT((DAZ/AZERO)**2+(DBET/BETA)**2+(X(IPOL)*DBET)**2)
8080 DELFN = (DAZ*INTRP4/AZERO)**2+(X(IPOL)*INTRP4*DBET)**2+(DBET*AZERO
    1*EXP(BETA*X(IPOL))/(BETA**3)*(2.0*BETA*B2-2.0*X(IPOL)))**2
8090 ERRE2 = SQRT(DELFN)
8100 ERRR2 = ERRE2/INTRP4
8120 GO TO ICOM,(2280,3640,4630)
     END
```

```
$IBFTC FTES
C
C             F TEST PROGRAM
C
      FUNCTION FTES(K,NEST,PE)
      DIMENSION F(18,7)
      IF(K-1.EQ.0) GO TO 5
      DATA((F(I,J),I=1,18),J=1,7)/1.00,.667,.585,.549,.528,.515,.506,.49
     19,.494,.490,.486,.484,.472,.469,.466,.463,.461,.458,.172,.133,.122
     2,.117,.113,.111,.110,.109,.108,2*.107,.106,2*.104,2*.103,2*.102,.0
     325,.020,.019,.018,7*.017,7*.016,.0062,.0046,.0044,2*.0043,2*.0042,
     44*.0041,5*.0040,2*.0039,.0015,.0013,.0012,3*.0011,9*.0010,3*.00099
     5,.00025,.0002,.00019,.00018,6*.00017,8*.00016,.000062,.00005,.0000
     646,.000044,2*.000043,3*.000042,.000041,4*.000040,4*.000039/
      GO TO 340
    5 IF(NEST.GT.120) GO TO 360
      IF(PE.GT.0.995.OR.PE.LT.0.50) GO TO 380
   10 DO 30 I = 1,12
   20 IF(NEST.EQ.I) GO TO 160
   30 CONTINUE
   40 IF(NEST.LE.15) GO TO 100
   50 IF(NEST.LE.20) GO TO 110
   60 IF(NEST.LE.30) GO TO 120
   70 IF(NEST.LE.40) GO TO 130
   80 IF(NEST.LE.60) GO TO 140
   90 IF(NEST.LE.120) GO TO 150
  100 I = 13
      GO TO 160
  110 I = 14
      GO TO 160
  120 I = 15
      GO TO 160
  130 I = 16
      GO TO 160
  140 I = 17
      GO TO 160
  150 I = 18
  160 IF(PE.EQ.0.50) GO TO 250
  170 IF(PE.LE.0.75) GO TO 260
  180 IF(PE.LE.0.90) GO TO 270
  190 IF(PE.LE.0.95) GO TO 280
  200 IF(PE.LE.0.975) GO TO 290
  210 IF(PE.LE.0.99) GO TO 300
  220 IF(PE.LE.0.995) GO TO 310
  230 WRITE(6,390)
  240 STOP
  250 J = 1
      GO TO 320
  260 J = 2
      GO TO 320
  270 J = 3
      GO TO 320
  280 J = 4
      GO TO 320
  290 J = 5
      GO TO 320
```

```
300 J = 6
    GO TO 320
310 J = 7
320 FTES = F(I,J)
330 RETURN
340 WRITE(6,350)
    GO TO 385
350 FORMAT(36H ONLY ONE SIDED F TEST NU 1 = 1 ONLY)
360 WRITE(6,370)
    GO TO 385
370 FORMAT(34H NU 2 IS TOO LARGE NU 2 = 120 MAX.)
380 WRITE(6,390)
385 STOP
390 FORMAT(92H LEVEL OF SIGNIFICANCE OUT OF RANGE 0.50 LESS THAN OR EQ
   1UAL TO PE LESS THAN OR EQUAL TO .995)
    END
```

```
$IBFTC WEXPFT
C              WEIGHTED EXPONENTIAL FIT  PROGRAM
      SUBROUTINE WEXPFT(X,Y,W,M,N,ALPHA,BETA,DAZ,DBET)
      DIMENSIONX(100),Y(100),W(100),H(100)
      DOUBLE PRECISION ZUCK,ZACK,ZORP,AKE,AKK,ARP,FARGO,APPLE
      NAG = 0
      N=N
      M = M
      DO 11 K = M,N
      IF(Y(K))12,11,11
   12 Y(K) = ABS(Y(K))
      NAG = 1
   11 CONTINUE
      IF(NAG) 13,60,13
   13 WRITE(6,6)
    6 FORMAT(77HJNEGATIVE Y VALUES HAVE BEEN MADE POSITIVE IN CALCILATIO
     1NS BEYOND THIS LINE. ///)
   60 DO 130 I = M,N
      H(I) = ALOG(Y(I))
  130 CONTINUE
      ZUCK = 0.0D0
      ZACK = 0.0D0
      ZORP = 0.0D0
      AKE  = 0.0D0
      AKK  = 0.0D0
      ARP  = 0.0D0
      DO 10 I = M,N
      ZUCK = ZUCK + W(I)
      ZACK = ZACK + X(I)*W(I)
      ZORP = ZORP + H(I)*W(I)
      AKE = AKE + X(I)*W(I)
      AKK = AKK + W(I)*X(I)**2
   10 ARP = ARP + X(I)*H(I)*W(I)
      FARGO = ZUCK*AKK - ZACK*AKE
      IF(FARGO) 30,20,30
   20 WRITE (6,8)
    8 FORMAT(30H DIVISION BY ZERO NO SOLUTION.)
      RETURN
   30 APPLE = (ZORP*AKK -ZACK*ARP)/FARGO
      ALPHA = DEXP(APPLE)
      BETA = (ZUCK*ARP -ZORP*AKE)/FARGO
      WRSQ = 0.0
   40 DO 50 I = M,N
   50 WRSQ = W(I)*((APPLE+BETA*X(I))-H(I))**2+ WRSQ
   52 WRSQ = WRSQ/ZUCK
   61 DBET = SQRT(ZUCK/FARGO)*SQRT(WRSQ/FLOAT(N-M))
   70 DAZ =                ALPHA*SQRT(AKK/FARGO)*SQRT(WRSQ/FLOAT(N-M))
      RETURN
      END
```

```
$IBFTC PARA
      SUBROUTINE PARA(X1,Y1,X2,Y2,X3,Y3,A1,A2,A3)
C           Y = A1*X**2 + A2*X + A3
      DOUBLE PRECISION XD1,XD2,XD3,YD1,YD2,YD3,DETD1,DETD2,DETD,DETN11,
     1DETN12,DETN1,DETN21,DETN22,DETN2,DETN31,DETN32,DETN3
      XD1 = X1
      XD2 = X2
      XD3 = X3
      YD1 = Y1
      YD2 = Y2
      YD3 = Y3
      DETD1 = XD1*XD1*XD2 + XD1*XD3*XD3 + XD2*XD2*XD3
      DETD2 = XD2*XD3*XD3 + XD1*XD1*XD3 + XD1*XD2*XD2
      DETD = DETD1 - DETD2
      DETN11 = YD1*XD2 + YD2*XD3 + YD3*XD1
      DETN12 = XD2*YD3 + XD3*YD1 +XD1*YD2
      DETN1 = DETN11 - DETN12
      A1 = DETN1/DETD
      DETN21 = XD1*XD1*YD2 + YD1*XD3*XD3 + XD2*XD2*YD3
      DETN22 = YD2*XD3*XD3 + YD3*XD1*XD1 + YD1*XD2*XD2
      DETN2 = DETN21 - DETN22
      A2 = DETN2/DETD
      DETN31 = XD1*XD1*XD2*YD3 + XD1*YD2*XD3*XD3 + YD1*XD2*XD2*XD3
      DETN32 = YD1*XD2*XD3*XD3 + YD2*XD1*XD1*XD3 + YD3*XD1*XD2*XD2
      DETN3 = DETN31 - DETN32
      A3 = DETN3/DETD
      RETURN
      END
```

```
$IBFTC HOWAGE
C          HOW ~~AGE PR~~OGRAM INPUTS AND OUTPUTS.
      SUBROUTINE HOWAGE
 1000 FORMAT(1H1,2X,13(1H*,3X),12HPROGRAM-ELLI,13(3X,1H*)///5X,109HA PRO
     XGRAM FOR THE COMPUTATION OF NEUTRON AGE FROM EXPERIMENTAL ACTIVATI
     XON DATA.  SEVEN OPTIONS ARE AVAILABLE.)
 1002 FORMAT(20X,27H1.  TRAPEZOIDAL QUADRATURE./20X,57H2.  POLYNOMIAL LE
     XAST-SQUARES FIT AND ANALYTIC QUADRATURE./20X,51H3.  AVERAGED PARAB
     XOLIC FIT AND ANALYTIC QUADRATURE./20X,97H4.  CHOICE OF DIVISION PO
     XINT BETWEEN OPTIONS 1,2, AND 3 QUADRATURES AND WEIGHTED EXPONENTIA
     XL FIT./20X,35H5.  ERROR OF OPTION ONE QUADRATURE./20X,35H6.  ERROR
     X OF OPTION TWO QUADRATURE./20X,37H7.  ERROR OF OPTION THREE QUADRA
     XTURE.///)
 1004 FORMAT(54X,12HINPUT-FORMAT//5X,61HFIRST CARD BLANK (OTHERWISE THIS
     X CODE DESCRIPTION IS PRINTED)/5X,90HSECOND CARD FORMAT(7I1) OPTION
     XS 1 THRU 7.  0 IF OPTION SKIPPED,1 IF OPTION TO BE EXECUTED.)
 1006 FORMAT(5X,65HOPTION 1 = TRAPEZOIDAL QUADRATURE AND OPTION 5 ERROR
     XIN OPTION 1./5X,76HOPTION 2 = LEAST-SQUARES ANALYTIC QUADRATURE AN
     XD OPTION 6 ERROR IN OPTION 2./5X,72HOPTION 3 = AVERAGED PARABOLIC
     XQUADRATURE AND OPTION 7 ERROR IN OPTION 3./5X,51HOPTION 4 = CHOICE
     X OF DIVISION POINT SEE IPOL BELOW.)
 1008 FORMAT(5X,115HTHIRD CARD FORMAT(A6,4X,A6,4X,8A6) TYPE OF DATA, UNI
     XTS, AND LABEL.  TYPE OF DATA = AS OR ASR**2 ACCORDING TO WHICH  /
     X1X,112HIS READ IN.  UNITS = INCH  IF R IN INCHES OR SIX BLANK SPAC
     XES IF R IN CMS.  LABEL MAY BE ANY ALPHAMERIC SYMBOL. )
 1010 FORMAT(5X,110HFOURTH CARD FORMAT(I8,12X,F10.3) NO. OF DATA POINTS
     XAND LEVEL OF SIGNIFICANCE BETWEEN (INCLUSIVE) .50 AND .995/
     X5X,92HFIFTH CARD ETC. FORMAT(3F15.4) R, AS OR ASR**2, AND SIGMA(AS
     X OR ASR**2) ACCORDING TO CARD 3./
     X5X,65HLAST CARD (IF OPTION 4) FORMAT(I8) INDEX OF DIVISION POINT (
     XIPOL))
 1012 FORMAT(5X,85HFOR MORE THAN ONE SET OF DATA REPEAT SEQUENCE STARTIN
     XG WITH CARD TWO OF INPUT-FORMAT.)
      WRITE(6,1000)
      WRITE(6,1002)
      WRITE(6,1004)
      WRITE(6,1006)
      WRITE(6,1008)
      WRITE(6,1010)
      WRITE(6,1012)
      STOP
      END
```

```
$IBFTC POYFZ
C       POLYNOMIAL LEAST SQUARES FIT
        SUBROUTINE POYFZ (X,Y,N,M,A)
        DIMENSION A(20),B(12,13),SUM(21),V(12),X(100),Y(100)
        COMMON IVDZEO
        IVDZEO = 0
        LS = 2*M + 1
        LB = M + 2
        LV = M + 1
        DO 5 J = 2,LS
      5 SUM(J) = 0.0
        SUM(1) = N
        DO 6 J = 1,LV
      6 V(J) = 0.0
        DO 16 I = 1,N
        P = 1.0
        V(1) = V(1) + Y(I)
        DO 13 J = 2,LV
        P = X(I)*P
        SUM(J) = SUM(J) + P
     13 V(J) = V(J) + Y(I) * P
        DO 16 J = LB,LS
        P = X(I) * P
     16 SUM(J) = SUM(J) + P
     17 DO 20 I = 1,LV
        DO 20 K = 1, LV
        J = K + I
     20 B(K,I) = SUM(J-1)
        DO 22 K = 1, LV
     22 B(K,LB) = V(K)
     23 DO 31 L = 1,LV
        DIVB = B(L,L)
        IF(DIVB) 25, 42, 25
     25 DO 26 J = L,LB
     26 B(L,J) = B(L,J)/DIVB
        I1 = L + 1
        IF(I1-LB) 28,33,33
     28 DO 31 I = I1,LV
        FMULTB = B(I,L)
        DO 31 J = L , LB
     31 B(I,J) = B(I,J) - B(L,J)*FMULTB
     33 A(LV) = B(LV,LB)
        I = LV
     35 SIGMA = 0.0
        DO 37 J = I , LV
     37 SIGMA = SIGMA + B(I-1,J)*A(J)
        I = I-1
        A(I) = B(I,LB) - SIGMA
     40 IF(I-1) 41,41,35
     42 WRITE (6,43)
    224 WRITE (6,225) DIVB,L
    225 FORMAT(E15.7,I6)
     43 FORMAT(45H DIVISION BY ZERO, DATA WILL NOT FIT CURVE.   )
        IVDZEO = 1
     41 RETURN
        END
```

SAMPLE PROBLEM AND OUTPUT

```
$DATA

1110111
AS                  TRIAL RUN
      30    .05     .75
      3.81         21607.          1600.
      5.08         20174.          2600.
      6.35         17112.          3400.
      7.62         13479.          4000.
      8.89          9970.          4000.
     10.16          7683.          6100.
     11.43          5490.          5400.
     12.70          4003.          4850.
     13.97          2971.          5850.
     15.24          2150.          7500.
     16.51          1525.          6250.
     17.78          1184.          5600.
     19.05           887.          4800.
     20.32           675.          8250.
     21.59           501.          7000.
     22.86           375.          5200.
     24.13           290.          2900.
     25.40           215.          5150.
     26.67           178.          5650.
     27.94           136.          6200.
     29.21           107.          3400.
     30.48            90.7         1850.
     31.75            65.3         3000.
     33.02            52.3         4400.
     34.29            34.2         3300.
     35.55            28.7        10000.
     36.83            23.2         5450.
     39.37            13.3         3600.
     40.64            11.2         5800.
     43.18            10.8         6150.
```

AGE MEASUREMENT BY FOIL ACTIVATION.

OPTION 1 LABEL =TRIAL RUN

	R	$A_S R^2$	ST. DEVIATION	PARTIAL SUM OF INTEGRAL 1	PARTIAL SUM OF INTEGRAL 2	
	0.	0.	23.2257595E 03			
	38.0999994E-01	31.3649364E 04	23.2257595E 03	39.8334684E 04	57.8226590E 05	
	5.0800000E-00	52.0618305E 04	67.0966387E 03	92.8094645E 04	17.2048042E 06	
	63.4999995E-01	68.9998598E 04	13.7096496E 04	16.9683635E 05	43.4034758E 06	
	76.1999989E-01	78.2650023E 04	23.2257595E 04	26.3196819E 05	89.9277468E 06	
	88.8999996E-01	78.7950029E 04	31.6128395E 04	36.2929921E 05	15.8328328E 07	
	1.0160000E 01	79.3082266E 04	62.9676147E 04	46.3325467E 05	24.9857059E 07	
	11.4299999E 00	71.7240477E 04	7.0548244E 05	55.9230952E 05	36.1344132E 07	
	12.6999999E 00	64.5643845E 04	78.2256479E 04	64.5774097E 05	48.6972337E 07	
	13.9699999E 00	57.9823012E 04	11.4169122E 05	72.3591242E 05	62.4954448E 07	
	15.2399999E 00	49.9353828E 04	17.4193196E 05	79.2118969E 05	77.0456753E 07	
****	16.5100000E 00	41.5684643E 04	17.0362558E 05	85.0223904E 05	91.6053410E 07	****

EXPONENTIAL REGION CALCULATIONS

R	$A_S R^2$	ST. DEVIATION	APPROXIMATION	PERCENTAGE DEV.
16.5100000E 00	41.5684643E 04	17.0362558E 05	43.4382992E 04	-1.0975620E-00
17.7800000E 00	37.4296021E 04	17.7031901E 05	37.1244106E 04	17.2393448E-02
19.0500000E 00	32.1894512E 04	17.4193196E 05	31.7282662E 04	26.4754746E-02
2.0320000E 01	27.8709116E 04	34.0644469E 05	27.1164668E 04	22.1475754E-02
21.5899999E 00	23.3530173E 04	32.6289659E 05	23.1750069E 04	54.5559869E-03
22.8599999E 00	19.5967345E 04	27.1741385E 05	19.8064494E 04	-77.1744928E-03
24.1299999E 00	16.8854494E 04	16.8854494E 05	16.9275227E 04	-24.9167461E-03
25.3999999E 00	13.8709396E 04	33.2257390E 05	14.4670558E 04	-17.9413977E-02
26.6699998E 00	12.6609422E 04	4.0187821E 06	12.3642260E 04	73.8323441E-03
27.9399998E 00	1.0616753E 05	48.3999014E 05	1.0567048E 05	1.0269524E-02
29.2099998E 00	91.2949762E 03	29.0096185E 05	9.0310961E 04	33.9203219E-03
3.0479999E 01	84.2630548E 03	17.1870618E 05	77.1839895E 03	41.1883388E-02
31.7500000E 00	65.8264799E 03	3.0241875E 06	65.9650602E 03	-45.8239036E-04
33.0200000E 00	57.0237560E 03	47.9740963E 05	56.3768435E 03	13.4846225E-03
34.2900000E 00	4.0212499E 04	38.8015342E 05	48.1822968E 03	-2.0539902E-01
35.5499997E 00	36.2711301E 03	12.6380247E 06	41.2298169E 03	-39.2362456E-03
36.8299999E 00	31.4696138E 03	73.9264631E 05	35.1933851E 03	-5.0371291E-02
39.3699999E 00	2.0614958E 04	55.7998867E 05	25.7060034E 03	-91.2375469E-03
4.0640000E 01	18.4980271E 03	95.7933540E 05	21.9695585E 03	-36.2397938E-03
43.1799998E 00	2.0136733E 04	11.4667509E 06	16.0470378E 03	35.6656866E-03

AGE COMPUTED BY TRAPEZOIDAL OPTION IS
45.3679805E 00SQUARE CMS.

AZERO = 33.4691639E 05

RELAXATION LENGTH = -8.0857326E-00

INTEGRAL 1 OVER EXPONENTIAL IS
35.1230474E 05

INTEGRAL 2 OVER EXPONENTIAL IS
23.5440016E 08

OPTION 5

FRACTIONAL ERROR IN INTEGRAL 1
OVER TRAPEZOIDAL RANGE
0.6019756E-02

FRACTIONAL ERROR IN INTEGRAL 2
OVER TRAPEZOIDAL RANGE
0.3180092E-03

FRACTIONAL ERROR IN CURVE I INTEGRATION
0.6028150E-02

ERROR IN AZERO =0.1781116E 06

ERROR IN BETA =0.2167722E-02

FRACTIONAL ERROR IN INTEGRAL 1
OVER EXPONENTIAL RANGE
0.6648373E-01

FRACTIONAL ERROR IN INTEGRAL 2
OVER EXPONENTIAL RANGE
0.6755616E-01

FRACTIONAL ERROR IN THE TOTAL INTEGRATION
0.5254653E-01

ERROR IN AGE IS EQUAL TO PLUS OR MINUS 11.91965E-01 SQUARE CMS.

AGE MEASUREMENT BY FOIL ACTIVATION.

OPTION 2 LABEL =TRIAL RUN

R	$A R^2_S$	STANDARD DEVIATION	APPROXIMATION	PERCENTAGE DEVIATION
0.	0.	0.2322576E 05	-0.6331250E 02	27.2596035E-02
0.3810000E 01	0.3136494E 06	0.2322576E 05	0.3139118E 06	-11.2984059E-01
0.5080000E 01	0.5206183E 06	0.6709664E 05	0.5234440E 06	-42.1135216E-01
0.6350000E 01	0.6899986E 06	0.1370965E 06	0.6843553E 06	41.1632395E-01
0.7620000E 01	0.7826500E 06	0.2322576E 06	0.7781188E 06	19.5092514E-01
0.8890000E 01	0.7879500E 06	0.3161284E 06	0.8053607E 06	-55.0745358E-01
0.1016000E 02	0.7930823E 06	0.6296761E 06	0.7794863E 06	21.5920639E-01
0.1143000E 02	0.7172405E 06	0.7054824E 06	0.7203117E 06	-43.5342598E-02
0.1270000E 02	0.6456438E 06	0.7822565E 06	0.6476909E 06	-26.1681869E-02
0.1397000E 02	0.5798230E 06	0.1141691E 07	0.5751425E 06	4.0996335E-01
0.1524000E 02	0.4993538E 06	0.1741932E 07	0.5034831E 06	-23.7052703E-02
0.1651000E 02	0.4156846E 06	0.1703626E 07	0.4144527E 06	72.3101673E-03

* *

SIGMA1 SQUARED = 0.1004194E 09 LEVEL OF SIGNIFICANCE =0.7500E 00

EXPONENTIAL REGION CALCULATIONS

R	$A R^2_S$	ST. DEVIATION	APPROXIMATION	PERCENTAGE DEV.
16.5100000E 00	41.5684643E 04	17.0362558E 05	43.4382992E 04	-1.0975620E-00
17.7800000E 00	37.4296021E 04	17.7031901E 05	37.1244106E 04	17.2393448E-02
19.0500000E 00	32.1894512E 04	17.4193196E 05	31.7282662E 04	26.4754746E-02
2.0320000E 01	27.8709116E 04	34.0644469E 05	27.1164668E 04	22.1475754E-02
21.5899999E 00	23.3530173E 04	32.6289659E 05	23.1750069E 04	54.5559869E-03
22.8599999E 00	19.5967345E 04	27.1741385E 05	19.8064494E 04	-77.1744928E-03
24.1299999E 00	16.8854494E 04	16.8854494E 05	16.9275227E 04	-24.9167461E-03
25.3999999E 00	13.8709396E 04	33.2257390E 05	14.4670558E 04	-17.9413977E-02
26.6699998E 00	12.6609422E 04	4.0187821E 06	12.3642260E 04	73.8323441E-03
27.9399998E 00	1.0616753E 05	48.3999014E 05	1.0567048E 05	1.0269524E-02
29.2099998E 00	91.2949762E 03	29.0096185E 05	9.0310961E 04	33.9203219E-03
3.0479999E 01	84.2630548E 03	17.1870618E 05	77.1839895E 03	41.1883388E-02
31.7500000E 00	65.8264799E 03	3.0241875E 06	65.9650602E 03	-45.8239036E-04
33.0200000E 00	57.0237560E 03	47.9740963E 05	56.3768435E 03	13.4846225E-03
34.2900000E 00	4.0212499E 04	38.8015342E 05	48.1822968E 03	-2.0539902E-01
35.5499997E 00	36.2711301E 03	12.6380247E 06	41.2298169E 03	-39.2362456E-03
36.8299999E 00	31.4696138E 03	73.9264631E 05	35.1933851E 03	-5.0371291E-02
39.3699999E 00	2.0614958E 04	55.7998867E 05	25.7060034E 03	-91.2375469E-03
4.0640000E 01	18.4980271E 03	95.7933540E 05	21.9695585E 03	-36.2397938E-03
43.1799998E 00	2.0136733E 04	11.4667509E 06	16.0470378E 03	35.6656866E-03

AGE COMPUTED BY POLYNOMIAL OPTION IS

45.8696127E 00SQUARE CMS.

AZERO = 33.4691639E 05

RELAXATION LENGTH = -8.0857326E-00

INTEGRAL 1 OVER EXPONENTIAL IS
35.1230474E 05

INTEGRAL 2 OVER EXPONENTIAL IS
23.5440016E 08

DEGREE OF EQUATION = 5

OPTION 6

FRACTIONAL ERROR IN INTEGRAL 1
OVER POLYNOMIAL RANGE
0.3612392E-06

FRACTIONAL ERROR IN INTEGRAL 2
OVER POLYNOMIAL RANGE
0.2143268E-07

FRACTIONAL ERROR IN CURVE I INTEGRATION
0.3618745E-06

ERROR IN AZERO =0.1781116E 06

ERROR IN BETA =0.2167722E-02

FRACTIONAL ERROR IN INTEGRAL 1
OVER EXPONENTIAL RANGE
0.6648373E-01

FRACTIONAL ERROR IN INTEGRAL 2
OVER EXPONENTIAL RANGE
0.6755616E-01

FRACTIONAL ERROR IN THE TOTAL INTEGRATION
0.5246418E-01

ERROR IN AGE IS EQUAL TO PLUS OR MINUS 12.03256E-01 SQUARE CMS.

AGE MEASUREMENT BY FOIL ACTIVATION.

OPTION 3 LABEL =TRIAL RUN

R	$A R^2_S$	ST. DEVIATION	PARTIAL SUM OF INTEGRAL 1	PARTIAL SUM OF INTEGRAL 2
0.	0.	23.2257595E 03		
38.0999994E-01	31.3649364E 04	23.2257595E 03	45.1170650E 04	36.9945121E 05
5.0800000E-00	52.0618305E 04	67.0966387E 03	98.0209846E 04	14.4706715E 06
63.4999995E-01	68.9998598E 04	13.7096496E 04	17.5500081E 05	4.0140324E 07
76.1999989E-01	78.2650023E 04	23.2257595E 04	26.9881523E 05	86.4896011E 06
88.8999996E-01	78.7950029E 04	31.6128395E 04	37.0077753E 05	15.4914529E 07
1.0160000E 01	79.3082266E 04	62.9676147E 04	47.0902677E 05	24.6536996E 07
11.4299999E 00	71.7240477E 04	7.0548244E 05	56.7214184E 05	35.8679900E 07
12.6999999E 00	64.5643845E 04	78.2256479E 04	65.3704309E 05	48.4462638E 07
13.9699999E 00	57.9823012E 04	11.4169122E 05	73.1568403E 05	62.2790976E 07
15.2399999E 00	49.9353828E 04	17.4193196E 05	8.0019057E 06	76.8942471E 07
**** 16.5100000E 00	41.5684643E 04	17.0362558E 05	85.8088722E 05	91.4575701E 07****

EXPONENTIAL REGION CALCULATIONS

R	$A R^2_S$	ST. DEVIATION	APPROXIMATION	PERCENTAGE DEV.
16.5100000E 00	41.5684643E 04	17.0362558E 05	43.4382992E 04	-1.0975620E-00
17.7800000E 00	37.4296021E 04	17.7031901E 05	37.1244106E 04	17.2393448E-02
19.0500000E 00	32.1894512E 04	17.4193196E 05	31.7282662E 04	26.4754746E-02
2.0320000E 01	27.8709116E 04	34.0644469E 05	27.1164668E 04	22.1475754E-02
21.5899999E 00	23.3530173E 04	32.6289659E 05	23.1750069E 04	54.5559869E-03
22.8599999E 00	19.5967345E 04	27.1741385E 05	19.8064494E 04	-77.1744928E-03
24.1299999E 00	16.8854494E 04	16.8854494E 05	16.9275227E 04	-24.9167461E-03
25.3999999E 00	13.8709396E 04	33.2257390E 05	14.4670558E 04	-17.9413977E-02
26.6699998E 00	12.6609422E 04	4.0187821E 06	12.3642260E 04	73.8323441E-03
27.9399998E 00	1.0616753E 05	48.3999014E 05	1.0567048E 05	1.0269524E-02
29.2099998E 00	91.2949762E 03	29.0096185E 05	9.0310961E 04	33.9203219E-03
3.0479999E 01	84.2630548E 03	17.1870618E 05	77.1839895E 03	41.1883388E-02
31.7500000E 00	65.8264799E 03	3.0241875E 06	65.9650602E 03	-45.8239036E-04
33.0200000E 00	57.0237560E 03	47.9740963E 05	56.3768435E 03	13.4846225E-03
34.2900000E 00	4.0212499E 04	38.8015342E 05	48.1822968E 03	-2.0539902E-01
35.5499997E 00	36.2711301E 03	12.6380247E 06	41.2298169E 03	-39.2362456E-03
36.8299999E 00	31.4696138E 03	73.9264631E 05	35.1933851E 03	-5.0371291E-02
39.3699999E 00	2.0614958E 04	55.7998867E 05	25.7060034E 03	-91.2375469E-03
4.0640000E 01	18.4980271E 03	95.7933540E 05	21.9695585E 03	-36.2397938E-03
43.1799998E 00	2.0136733E 04	11.4667509E 06	16.0470378E 03	35.6656866E-03

AGE COMPUTED BY PARABOLIC OPTION IS
45.0525637E 00SQUARE CMS.

AZERO = 33.4691639E 05

RELAXATION LENGTH = -8.0857326E-00

INTEGRAL 1 OVER EXPONENTIAL IS
35.1230474E 05

INTEGRAL 2 OVER EXPONENTIAL IS
23.5440016E 08

OPTION 7

FRACTIONAL ERROR IN INTEGRAL 1
OVER SMOOTHED PARABOLIC RANGE
0.1607089E-03

FRACTIONAL ERROR IN INTEGRAL 2
OVER SMOOTHED PARABOLIC RANGE
0.1027274E-04

FRACTIONAL ERROR IN CURVE I INTEGRATION
0.1610369E-03

ERROR IN AZERO =0.1781116E 06

ERROR IN BETA =0.2167722E-02

FRACTIONAL ERROR IN INTEGRAL 1
OVER EXPONENTIAL RANGE
0.6648373E-01

FRACTIONAL ERROR IN INTEGRAL 2
OVER EXPONENTIAL RANGE
0.6755616E-01

FRACTIONAL ERROR IN THE TOTAL INTEGRATION
0.5234727E-01

ERROR IN AGE IS EQUAL TO PLUS OR MINUS 11.79189E-01 SQUARE CMS.

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