75201 - RADIOACTIVE DECAY

Calculates the mass loss between any two times given the half-life, initial mass and present mass; displays the decay curve; or calculates the age of the mass based upon the present mass.

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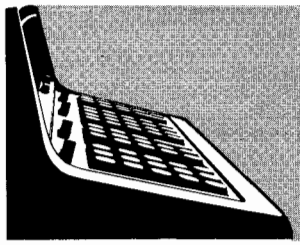

PART NO.
09100-75201

RADIOACTIVE DECAY

Given a number of activity readings at various times from a Geiger-Mueller counter or similar radioactivity-measuring device, this program calculates the decay constant (λ), the half-life (τ), and, if desired, a set of M/M_o values versus time. M_o is the original mass of the sample and M is the mass remaining after a time t.

The equation for activity is:

$$1)\quad A = \frac{-dN}{dt} = \lambda N_o e^{-\lambda t}$$

Taking the natural logarithm of both sides of equation (1), the following equation results.

$$2)\quad \ln A = \ln \lambda N_o - \lambda t$$

Since equation (2) is a linear function of t, a linear regression (method of least squares) is performed on the set of ln A and t to obtain the slope ($-\lambda$) of the ln A versus t line.

The following equation is used to solve for λ (see Program 09100-70811).

$$\lambda = \frac{-\left[n \cdot \sum_{i=1}^{n} (\ln A_i)(t_i) - \left(\sum_{i=1}^{n} t_i\right)\left(\sum_{i=1}^{n} \ln A_i\right)\right]}{n \cdot \sum_{i=1}^{n} (t_i)^2 - \left(\sum t_i\right)^2}$$

Given λ, the half-life τ is calculated from the equation:

$$\tau = \ln 2 / \lambda$$

The fraction of mass remaining at time t is:

$$\frac{M}{M_o} = e^{-\lambda t}$$

The fraction of mass at any time t is easily obtained by entering the desired t in the Y register at the correct display during program execution (see "User Instructions"). M/M_o is calculated for the value of time appearing in the Y register before incrementing that time by the amount entered in the X register for the next calculation. A decay curve (M/M_o versus t) may also be obtained for any initial time and any increment (Δt).

USER INSTRUCTIONS

ENTER PROGRAM (Starting Address is 0 - 0)

PRESS: GO TO (0) (0) [or END]

PRESS: CONTINUE

DISPLAY

0	Z
0	Y
i	X

ENTER DATA: $t_i \rightarrow Y$, $A_i \rightarrow X$

PRESS: CONTINUE

Has all data been entered? NO / YES

PRESS: SET FLAG

PRESS: CONTINUE

DISPLAY

0	Z
τ	Y
λ	X

Wish to plot a decay curve? NO / YES

PRESS: CONTINUE

DISPLAY

0	Z
0	Y
0	X

ENTER DATA: t(initial) $\rightarrow$ Y, $\Delta t \rightarrow$ X

YES

USER INSTRUCTIONS (con't)

PRESS: CONTINUE

DISPLAY:

t	Z
λ	Y
M/M_o	X

PRESS: CONTINUE

DISPLAY

0	Z
$t + \Delta t$	Y
Δt	X

Wish to change t or Δt? NO / YES

To reset problem:

EXAMPLES

A) Calculate λ, τ and the value of M/M_O at $t = \tau$ for following set of data. (M/M_O should be equal to .5 at $t = \tau$)

Data:

i	t_i (minutes)	A_i(counts/minute)
1	.1	5.6×10^7
2	.3	5.01×10^7
3	.5	4.44×10^7
4	1	3.29×10^7
5	10	1.48×10^5

Solution: $\tau = 1.15491$

$\lambda = .60018$

M/M_O (for $t = 1.15491$) = .50000

B) Calculate λ, τ and a set of M/M_O values for t (initial) = 0, $\Delta t = .2$, using the following data.

Data:

i	t_i (minutes)	A_i (counts/min.)
1	1	4.01×10^5
2	1.5	3.80×10^5
3	4	2.61×10^4
4	4.5	2.11×10^4

Solution: $\tau = .75422$

$\lambda = .91903$

Δt	t	M/M_O
.2	0	1.00000
.2	.2	.83210
.2	.4	.69239
.2	.6	.57613
.2	.8	.47940
.2	1.0	.39891

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Step		Key	Code	Display x	Display y	Display z	Storage f	Storage e	Storage d	Storage c	Storage b	Storage a	
0	0	CLEAR	20										CLEAR STORAGE AND DISPLAY REGISTERS
	1	$x\rightarrow( )$	23										
	2	c	16										
	3	$x\rightarrow( )$	23										
	4	b	14										
	5	1	01										INITIALIZE COUNTER
	6	$x\rightarrow( )$	23										
	7	a	13										
	8	STOP	41	A_i	t_i	0							ENTER DATA
	9	IF FLAG	43										
	a	2	02										
	b	9	11										
	c	ln x	65										CALCULATE $\Sigma \ln(A_i)$ AND Σt_i
	d	ACC +	60										
1	0	$x\rightleftarrows y$	30										CALCULATE $\Sigma (t_i)^2$
	1	×	36										
	2	↑	27										
	3	×	36										
	4	b	14										
	5	+	33										
	6	$y\rightarrow( )$	40										
	7	b	14										
	8	c	16										CALCULATE $\Sigma t_i \cdot \ln(A_i)$
	9	ROLL ↑	22										
	a	+	33										
	b	$y\rightarrow( )$	40										
	c	c	16										
	d	CLEAR x	37										
2	0	↑	27										
	1	a	13										INCREMENT COUNTER
	2	↑	27										
	3	1	01										
	4	+	33										
	5	↓	25										
	6	GO TO( )( )	44										BRANCH TO ENTER NEXT DATA SET
	7	0	00										
	8	6	06										
	9	a	13										DECREMENT n
	a	↑	27										
	b	1	01										
	c	−	34										
	d	$y\rightleftarrows( )$	24										

Step		Key	Code	Display x	Display y	Display z	Storage t	Storage e	Storage d	Storage c	Storage b	Storage a	
3	0	C	16										CALCULATE λ
	1	C	16										
	2	×	36										
	3	↑	27										
	4	RCL	61										
	5	x⇄y	30										
	6	×	36										
	7	ROLL ↓	31										
	8	−	34										
	9	y⇄( )	24										
	a	b	14										
	b	C	16										
	c	×	36										
	d	↓	25										
4	0	ROLL ↓	31										
	1	×	36										
	2	↓	25										
	3	−	34										
	4	b	14										
	5	x⇄y	30										
	6	÷	35										
	7	|y|	55										
	8	2	02										CALCULATE τ
	9	ln x	65										
	a	x⇄y	30										
	b	÷	35										
	c	↑	27										
	d	CLEAR x	37										
5	0	y→( )	40										STORE λ
	1	a	13										
	2	ROLL ↓	31										
	3	STOP	41	λ	τ	0							DISPLAY
	4	CLEAR	20										
	5	STOP	41	Δt	t(INITIAL)	0							ENTER DATA: t(INITIAL)→Y, Δt→X
	6	↑	27										CALCULATE M/M_0
	7	↓	25										
	8	x→( )	23										
	9	C	16										
	a	a	13										
	b	CHG SIGN	32										
	c	×	36										
	d	↓	25										

Step	Key	Code	Display x	Display y	Display z	Storage f	Storage e	Storage d	Storage c	Storage b	Storage a
6 0	e^x	74									
1	↑	27									
2	∂	13	RECALL AND POSITION λ AND t								
3	$x \rightleftarrows y$	30									
4	STOP	41	M/M_0	λ	t	DISPLAY					
5	CLEAR x	37									
6	ROLL ↓	31	INCREMENT t								
7	Σ	16									
8	+	33									
9	GO TO( )( )	44									
a	5	05	BRANCH TO DISPLAY t AND Δt FOR NEXT								
b	5	05	M/M_0 CALCULATION.								
c	END	46									
d											
0											
1											
2											
3											
4											
5											
6											
7											
8											
9											
a											
b											
c											
d											
0											
1											
2											
3											
4											
5											
6											
7											
8											
9											
a											
b											
c											
d											

Step	Key	Code	Display			Storage					
			x	y	z	f	e	d	c	b	a
0											
1											
2											
3											
4											
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6											
7											
8											
9											
a											
b											
c											
d											
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3											
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