MODERN PHYSICS DAY 12: LAB: HALF-LIFE ANALOGUE

CED 15.8 · Skills 3.A/2.D · FRQ: Experimental Design · guided physical investigation: extract a half-life from survivor data

RETRIEVE

What fraction of a large sample is expected to remain after two half-lives?

A. 1/4 B. 1/2 C. zero D. 3/4

PHYSICAL MODEL

Each unremoved coin or token represents one undecayed nucleus. Toss all survivors once per trial. Remove every marked-side result; return the unmarked survivors for the next trial.

$$N = N_0\left(\frac{1}{2}\right)^{t/T_{1/2}}$$

Do not take $\ln 0$. End the run while at least one survivor remains.

NOTES / REASONING

COLLECT A SURVIVOR RECORD

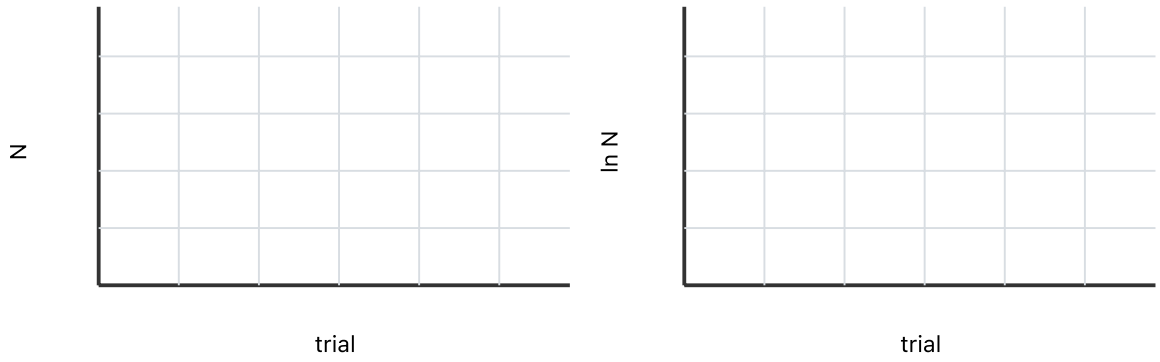
1. Count and record N_0.
2. Toss all current survivors once.
3. Remove marked-side results and count the survivors.
4. Repeat, recording every trial without replacing removed tokens.

trial t	**survivors** N	**fraction** N/N_0	$\ln N$**, only if** $N > 0$
1			
2			
3			
4			
5			
6			
7			

> Your counts are one random record. Do not alter them to force exact halving.

GRAPH THE SAME DATA TWO WAYS

SURVIVORS AND LINEARIZED SURVIVORS



1. Plot N versus trial on the left. Draw a smooth exponential trend.

2. Plot $\ln N$ versus trial on the right. Draw one best-fit line through all positive-count trials.

EXTRACT AND EVALUATE THE HALF-LIFE

$$\ln N = \ln N_0 - \lambda_d t \qquad T_{1/2} = \frac{\ln 2}{\lambda_d} = \frac{-\ln 2}{\text{slope}}$$

1. Calculate the best-fit slope with units and determine $T_{1/2}$ in trials.

2. Compare the result with the expected one-trial half-life for a two-sided token. Calculate percent difference.

3. Explain why a finite group need not halve exactly on each trial or reach zero after one half-life.

4. Predict how increasing N_0 would affect relative fluctuation in the fitted result.