

Unstable nuclei, decay and half-life

Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Lab

Name: _____ Date: _____ Class: _____

Can a random process give a regular pattern? In this lab each die is a nucleus and each throw is a time interval. The dice that show a six decay and are removed. You plot the dice left against the throw number and read off the half-life of your model. It takes about 25 minutes with school equipment.

Level: Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** HS-PS1-8, GCSE P4

Aim

To model radioactive decay with dice, to see that decay is random but follows a predictable pattern, and to measure the half-life of the model.

Equipment

- 100 identical dice (or 100 small cubes with one face marked)
- a large tray or shallow box
- a cup or tub for the removed dice
- graph paper or a spreadsheet

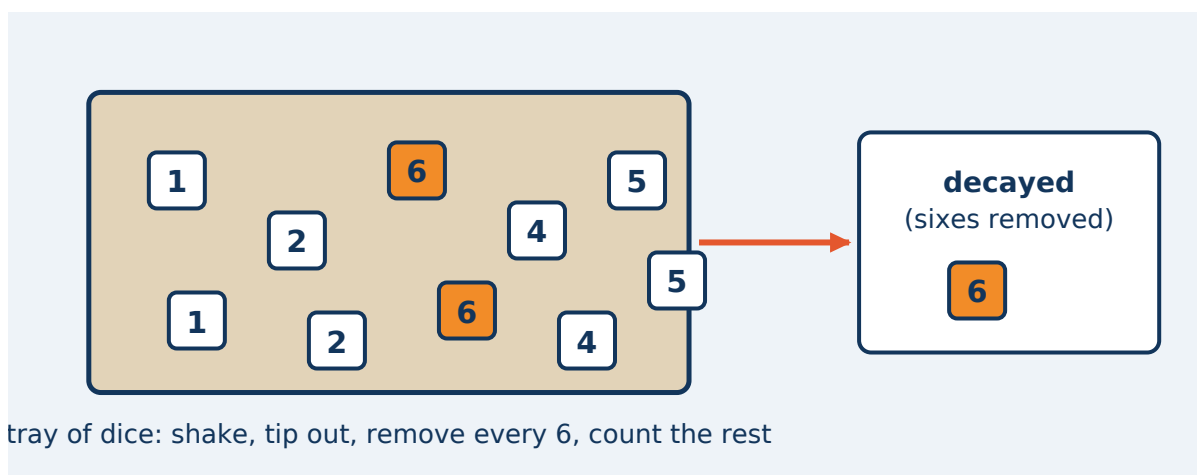
Safety

Safety

Throw the dice gently inside the tray so none fall on the floor, where someone could slip on them. No real radioactive material is used in this lab.

Method

1. Put all 100 dice in the tray and record 100 as the number at throw 0.
2. Shake the tray, tip the dice out gently and spread them in one layer.
3. Remove every die showing a six. These have "decayed".
4. Count the dice that are left and record the number.
5. Return only the remaining dice to the tray and repeat until fewer than 10 dice remain.



Dice model of decay: every die showing a six has 'decayed' and is removed before the next throw.

Results

Sample results from one group:

Throw number	Dice left	Dice removed
0	100	–
1	85	15
2	68	17
3	58	10
4	49	9
5	40	9
6	34	6
7	28	6
8	22	6
9	20	2
10	16	4

Analysis questions

Question 1 The analogy

Say what each of these represents in real radioactive decay: a die, a throw, and a six.

Question 2 Plotting the curve

Plot the dice left (y-axis) against the throw number (x-axis) and draw a smooth curve. Describe its shape.

Question 3 Half-life of the model

Use the graph to find the number of throws for the dice left to fall from 100 to 50 and from 50 to 25. Calculate the mean half-life.

Question 4 Prediction

The chance of a die decaying is 1 in 6, so the number left should be multiplied by $\frac{5}{6}$ each throw. Calculate the expected number left after throw 1 and throw 5 and compare with the sample results.

Question 5 Why not identical?

Explain why the sample results do not match the predicted values exactly, and say how the results could be made closer to the prediction.

Question 6 A different rule

Suppose both fives and sixes are removed, so the chance of decay is 1 in 3 and the number left is multiplied by $\frac{2}{3}$ each throw. Calculate the new half-life in throws and explain the change.

Question 7 Limits of the model

State two ways in which the dice model is different from the decay of real nuclei.