

Introduction:

This simulation is written in JavaScript and incorporated within an html file. The webpage does not hyperlink to any other pages, which means the simulation can be played off-line. No special plugins are needed and the file size is very small, about 9KB.

The simulation works by creating an array (of atoms) whose size is the chosen sample size. Each atom in the array is polled 20 times a second. If an atom has not already decayed a random function is called and it is given a chance of decaying set by the "Probability of decay" value. At the end of each pass-through of the array the number of atoms remaining is calculated as a percentage of the original number and displayed on the graph. The range along the x-axis is 30 seconds and is 600 pixels long. This means each 20th of a second occupies one pixel along the x-axis. The displays of "Elapsed time" and "Atoms remaining" are updated each 20th of a second also.

Ideas about using the simulation with students:

1. You could start by getting students to look at the decay of 1 000 atoms and then ask: "What will the decay of 100 atoms look like?" Many will think the decay will be faster (or slower for 10 000 atoms). Students then could run decays of the other sample sizes and find that the decay rate remains the same. You can help to explain this by showing the smaller sample sizes are subsets (in the top right-hand corner) of the 10 000 atoms sample. When running the 10 000 atoms decay they can focus on the atoms in a notional 100 atom square in the top right-hand corner and see that they do not decay *in total* any faster than the whole 10 000 atom sample.
2. The simulation does show a greater variation in decay with smaller sample size. Students can run the same decay of 100 atoms several times to get a feel for that randomness. They can also use the elapsed timer to record when the sample decays completely to zero and see that there is a wide variation in that measured time. For this purpose, the elapsed timer has been made to continue past 30 seconds and only stops when "Stop" or "Reset" is pressed.
3. Students can choose to display the theoretical decay curve at any time. If not chosen before starting a decay, the decay can be stopped, the "Show theoretical decay curve" selected and then the decay resumed by pressing "Go". You can do this even after the plotting has stopped at 30 s.
4. Students can choose different values for "Probability of decay". The range of choice has been restricted to produce decay curves that display easily on the graph. The "probability of decay" is a quantity used in the program to generate the decay. It is not an intrinsic physical quantity since the decay is also heavily influenced by how many times the atoms are polled (here 20 times a second) which is chosen arbitrarily.

However, different probability values lead to different decay rates and hence different half-lives. Students can estimate these from the graph or by stopping the decay as close as they can when 50%, 25%, 12.5%, etc., are reached.

Decays are engineered to take seconds to tens of seconds. You could say that the simulation is running at "fast forward" and instead of seconds read "years" or "thousands of years".

5. It is possible to “break” the simulation by entering a probability less than 0.001 (by entering a value such as .0005) and pressing “OK” to the error messages that pop up when you press “Reset” and “Go”. Values between .0009 and .0001 will give valid decay curves.
6. I’m happy to receive corrections and consider suggestions about improvements or changes. Two possible additions are:
 - a) enable the decays of all three sample sizes to be displayed on the same graph and
 - b) also display “activity” (decays per 20th second or decays per second).

Overall, I think this simulation compares well with other simulations such as the ones listed below.

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Other On-line Radioactive Decay Simulations:

<http://phet.colorado.edu/en/simulation/alpha-decay>

<https://phet.colorado.edu/en/simulations/beta-decay>

https://www.walter-fendt.de/html5/phen/lawdecay_en.htm

<http://physics.bu.edu/~duffy/HTML5/halflife.html>

<https://www.softpedia.com/get/Science-CAD/Radioactive-Dice-Decay-Simulation.shtml>

<https://teachchemistry.org/classroom-resources/half-life-investigation-simulation>

<https://www.edumedia-sciences.com/en/media/527-radioactive-decay>

<https://iwant2study.org/ospsg/index.php/interactive-resources/physics/06-quantum-physics/02-nuclear/315-decaychangenwee>