COLLEGE of CHARLESTON

Project-based learning for Honors College students

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Calculus-based physics for Honors College is different from the regular classes because of the required immersive experience. Each student, or group of a maximum of three students, must pick up a project for the end-of-semester report and presentation. Since the campus closed before they completed their projects, we moved to a hybrid approach with some experiments carried out by the instructor and others based on simulations. To ensure equitable effort, the entire team had to coordinate both on writing the final report and on recording a VoiceThread video with their presentation for the entire class. All presentations were discussed and evaluated by the entire class during a zoom conference.

158 L description

COURSE PHILOSOPHY

“Honors 158 Lab complements the corresponding lecture of the second part of a one-year introductory course in physics for students with broad interests. In addition to running standard labs, students will be completing projects on course-related topics with the objective of providing a research-oriented experience. Laboratory three hours per week.”

Specific Honors Learning Outcome - Foundations of Knowledge and Methods of Inquiry

1. Demonstrate the ability to create and communicate analytic arguments supported by evidence.
2.Analyze and synthesize information within and/or across disciplines.
3. Design and implement a major research project that reflects a high level of proficiency in methods of inquiry and ways of thinking.

Lab Research Project:

"During the semester, you will be required to design and carry out an experiment of some aspect of physics from this semester's topics. After consulting with your instructor you must decide on your topic by **March 12**. A detailed outline is due by **March 26**. The oral presentations will be on **April 16**. Written reports on your projects are due on **April 20."**

Projects are typically selected by the students and drive them to investigate, do research, and construct their own solutions.

PBL

Advantages:
-Foster active learning
-Students work in groups, communicate and engage
-Integrates content area
-enhances long term memory
-Improve problem solving skills
-Provides relevance

Steps:
1. Identify a problem/topic
2. Develop a plan to solve it
3. Implement the plan in finding a solution
4. Evaluate the implementation and make a presentation

Sample project # 1

Spring 2018-sample project onsite

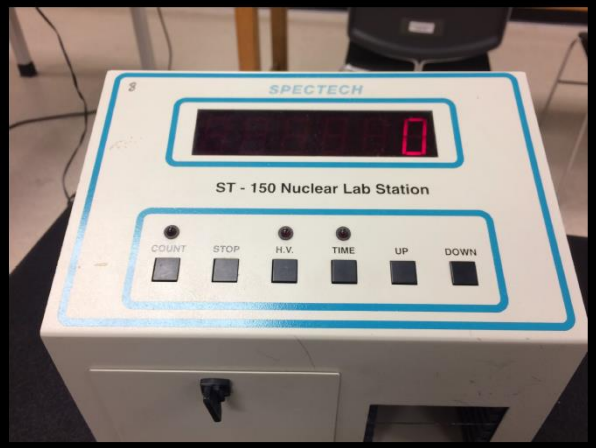
“THE PREVALENCE OF RADIATION IN EVERYDAY LIFE”

1.Recorded data related to alpha, beta and gamma radiation in the lab using the Nuclear lab station detector
2.Using a digital Vernier radiation monitor students measured radiation on campus, different location across the city, car, historic houses, dormitory.
3. Other application of radiation "How radiation affect flight space travel”?

Experiments

How We Measured Radiation in the Lab

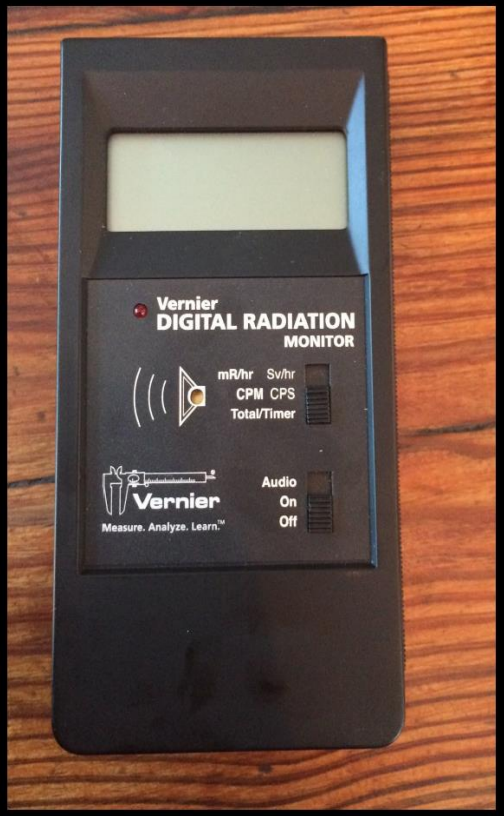
- Used a Spectech ST150 Nuclear Lab Station
- Measured radiation at different distances
- Measured radiation at different voltages
- Inserted different objects to be used as shielding
- Paper, cloth, leaf, wood, plastic, aluminium, lead
- Background radiation: 3 cpm at 520 V



Experiments

How We Measured Radiation Outside the Lab

- Vernier Digital Radiation Monitor
- Voltage: 9 V
- Set device to 5 minutes and allow to count
- Counter measured gamma radiation for 5 minutes
- Each count is a particle hitting the counter
- Background radiation
- Differences in radiation measures vs location



COLLEGE of CHARLESTON

Data

Location	Count	CPM		Location	Count	CPM
Dorm room 1	79	15.8		New Car	76	15.2
Dorm room 1	103	20.6		Quartz Countertop	57	11.4
Dorm room 1	110	22		Dorm Room 2	97	19.4
Historical house	57	11.4		Dorm Room 2	97	19.4
Historical house	52	10.4		Dorm Room 2	86	17.2
Historical house	56	11.2		Old Car	104	20.8
SMB	87	17.4		Old Car	96	19.2
SMB	85	17		Old Car	85	17
SMB	74	14.8		Granite	77	15.4
Cooper River	86	17.2		Granite	81	16.2
Cooper River	84	16.8		Granite	77	15.4
Cooper River	98	19.6		Dorm Lobby	77	15.4
Lobby 1	104	20.8		Dorm Lobby	83	16.6
Lobby 1	100	20		Dorm Lobby	79	15.8
Lobby 1	88	17.6		Randolph Hall	107	21.4

5. Outside Radiation

Applications

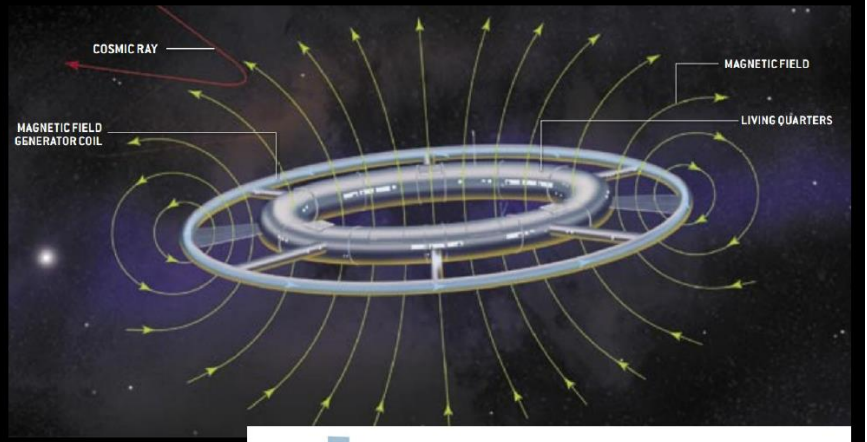
Fighter Jets

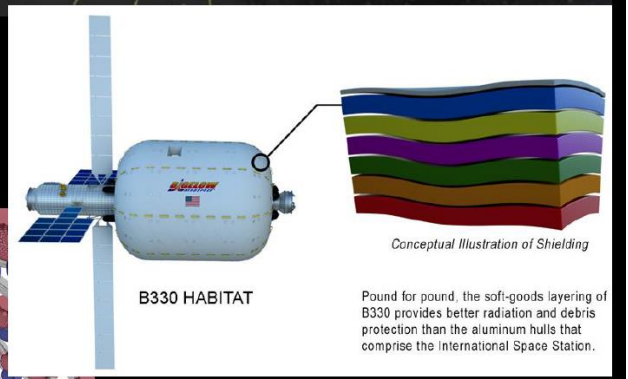
- Original testing grounds for spaceflight technology
- Radiation experienced by rocket pilots
- 3 mSv annually
- Changes in genetic expression
- LDR and hormesis
- Lead glass
- Stealth technology

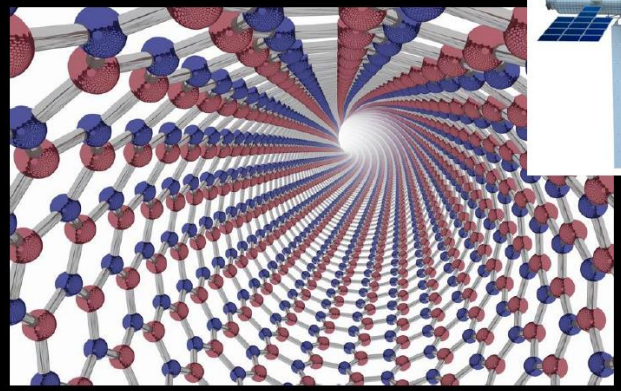
Applications

Spacecrafts

- No atmosphere or magnetosphere in space
- Can’t build out of lead
- Weight
- Design
- Packing
- Material, thickness
- Hydrogenated BNNT’s







Sample project # 2

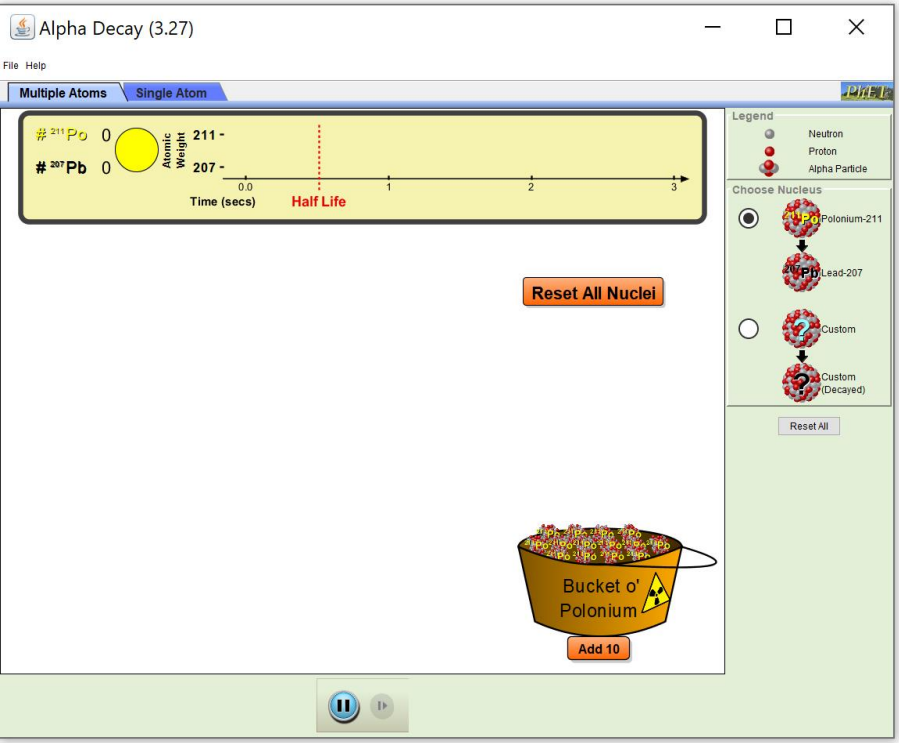
Spring 2020-sample project remote setting:
Alpha and Beta Decay simulation
Simulations:

- https://phet.colorado.edu/en/simulation/alpha-decay
- https://phet.colorado.edu/en/simulation/beta-decay

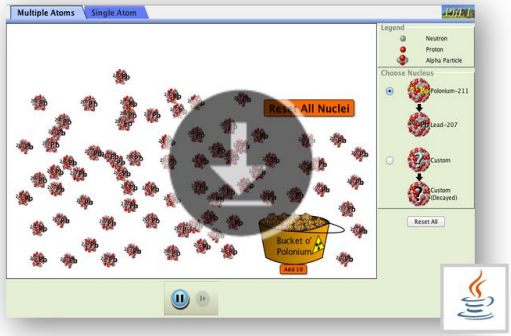
Simulations

PhET INTERACTIVE SIMULATIONS | University of Colorado Boulder

SIMULATIONS TEACHING RESEARCH ACCESSIBILITY



Alpha Decay



- Alpha Decay
- Half Life
- Radiation

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- SOFTWARE REQUIREMENTS
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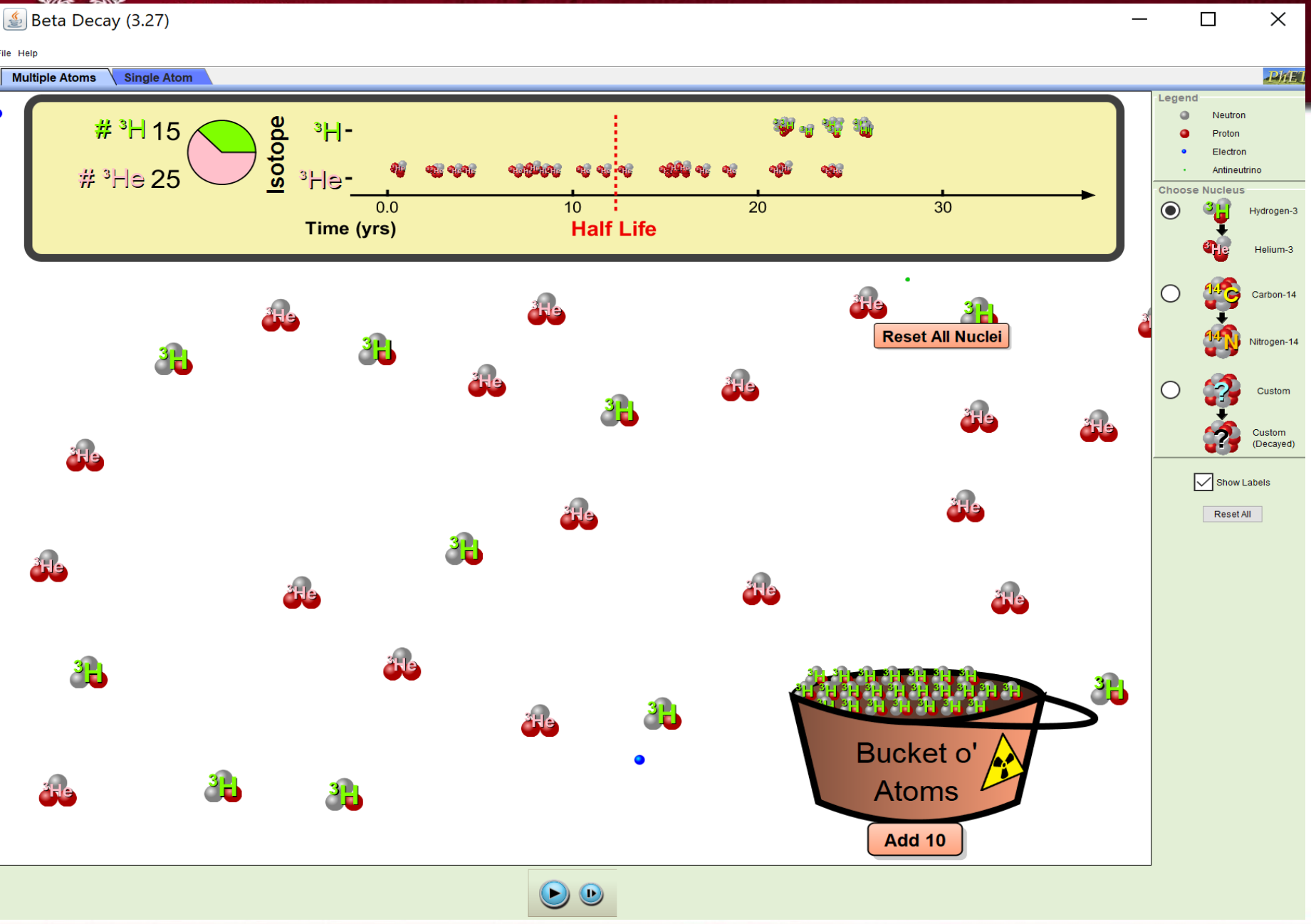
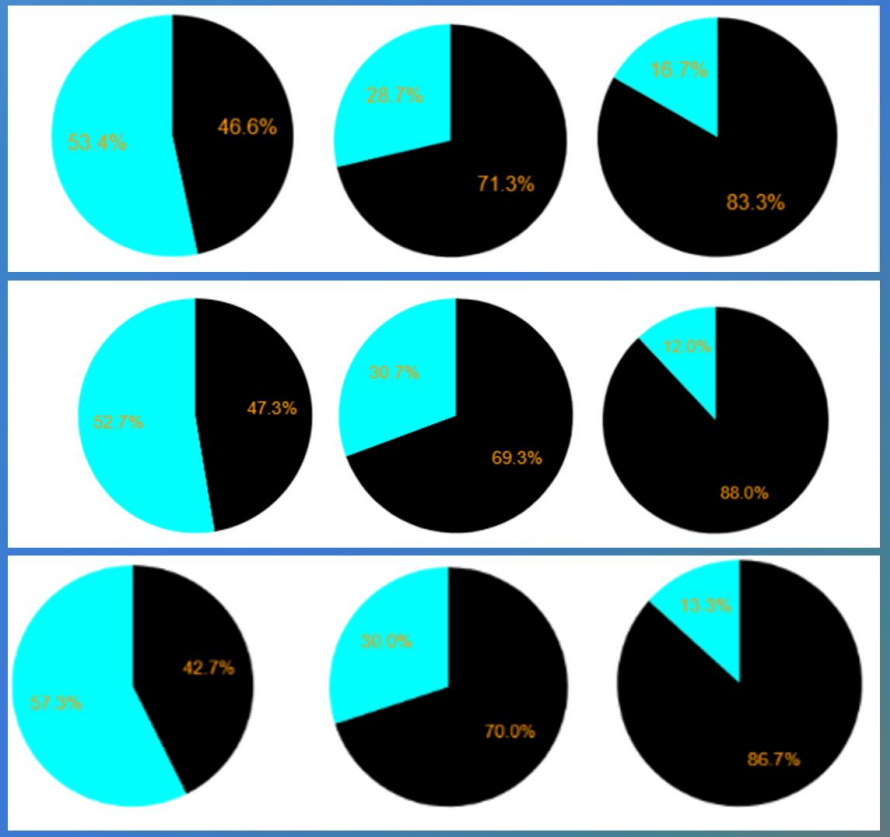

Beta Decay (3.27)
File Help
Multiple Atoms
Single Atom
PhET
³H 15
³He 25
Isotope
³H-
³He-
0.0
10
20
30
Time (yrs)
Half Life
Legend
Neutron
Proton
Electron
Antineutrino
Choose Nucleus
Hydrogen-3
Helium-3
Carbon-14
Nitrogen-14
Custom
Custom (Decayed)
Show Labels
Reset All
Reset All Nuclei
Bucket o' Atoms
Add 10

Results

Constant Starting Atoms (Alpha)

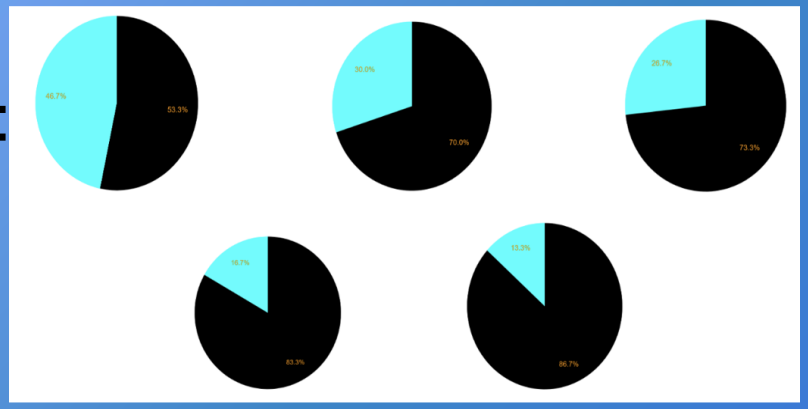
- 0.5s half-life
- 0.75s half-life
- 1s half-life



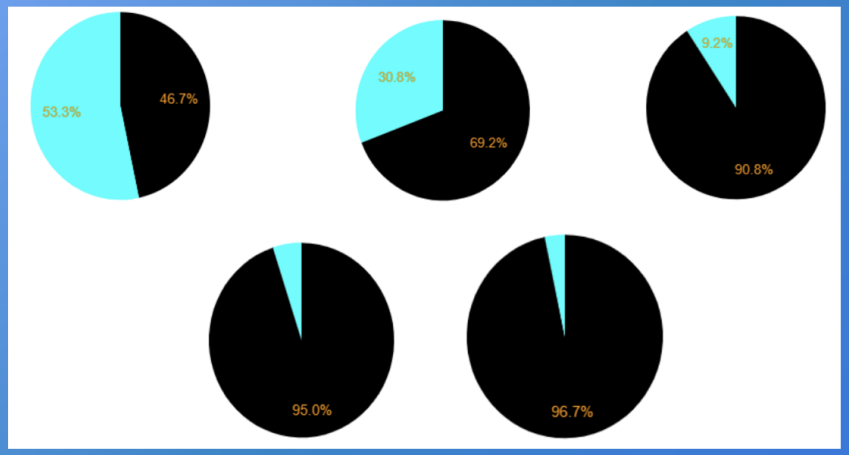
Results

Constant Half-life (Alpha)

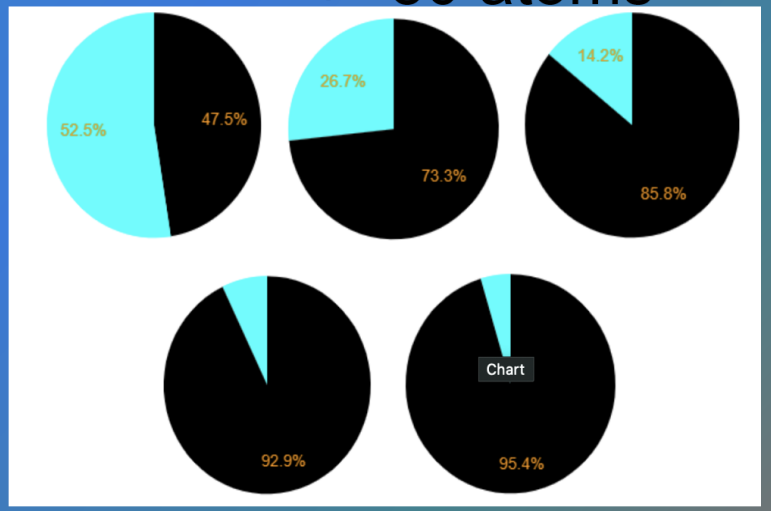
- 10 atoms:



- 40 atoms:



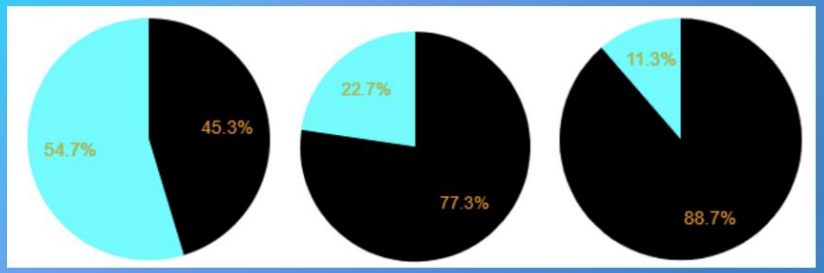
- 80 atoms



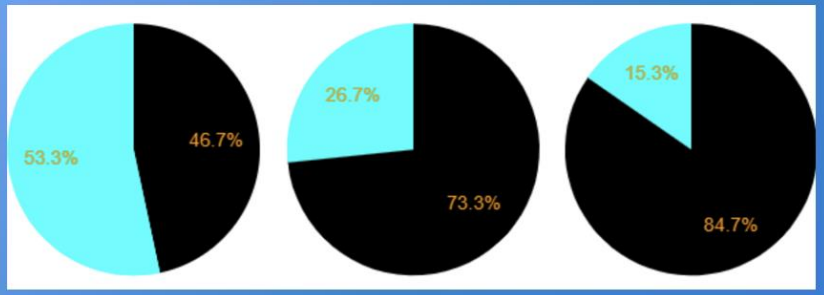
Results

COLLEGE of

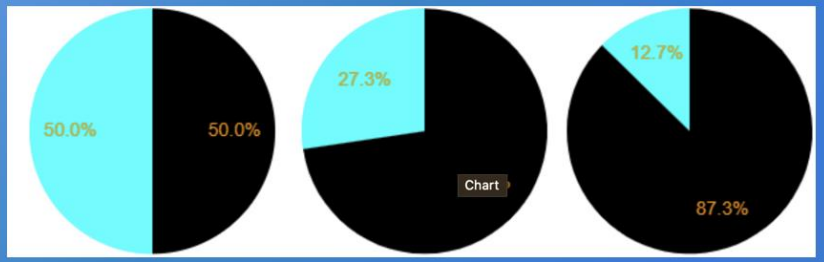
Constant Starting Atoms (Beta)



- 50 atoms, 5 year half life



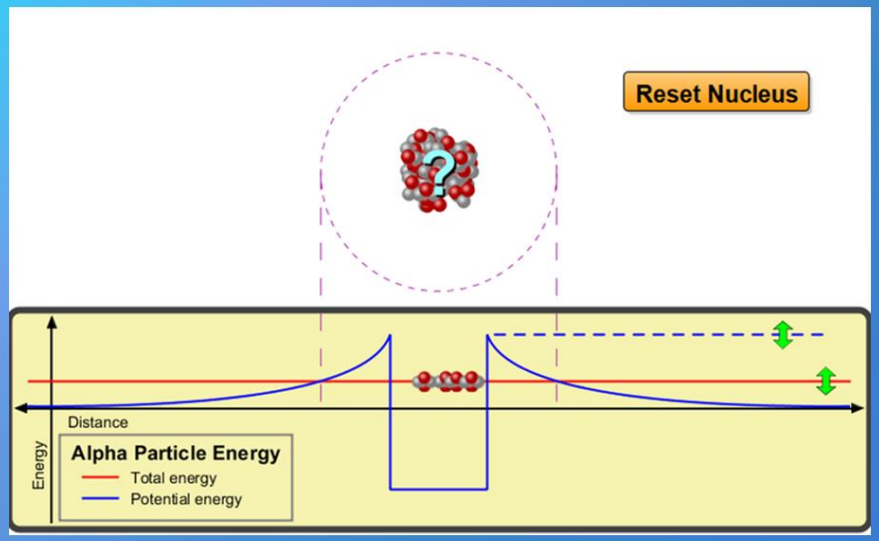
- 50 atoms, 7.5 year half life

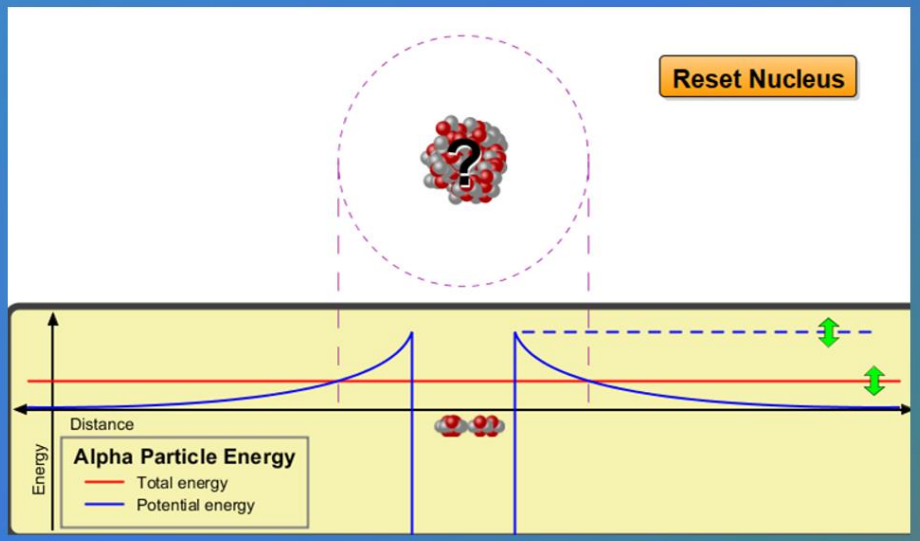


- 50 atoms, 10 year half life

Results

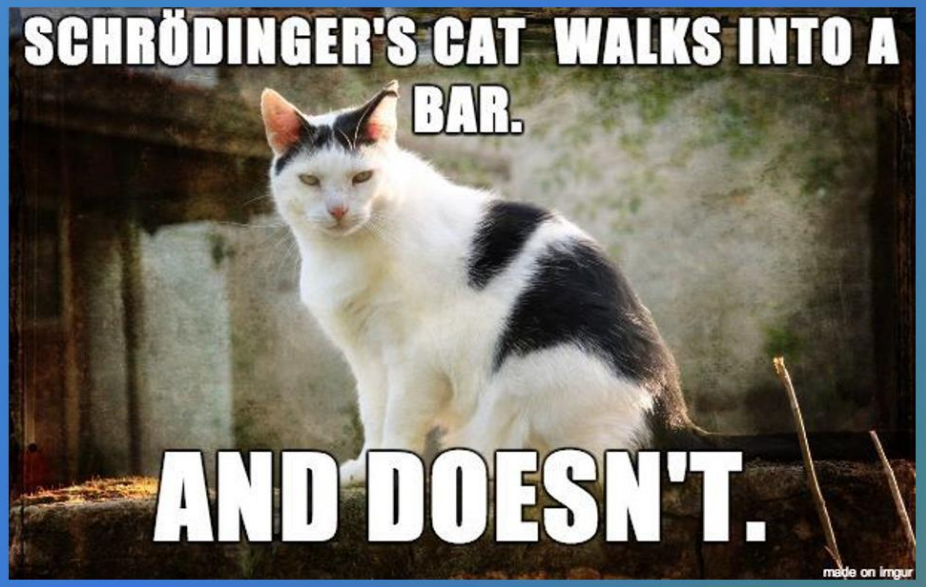
Energy graphs

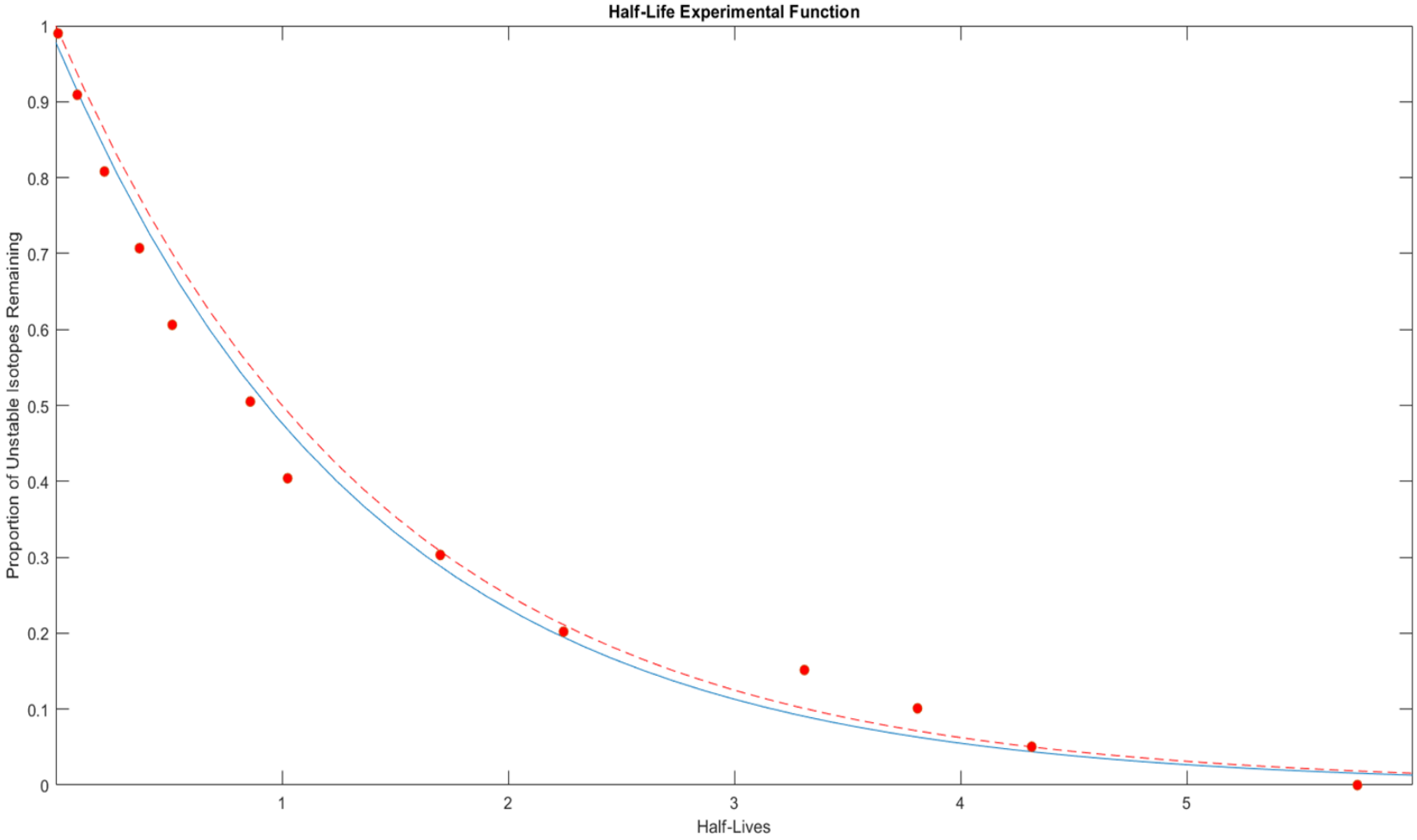




Schrodinger's Cat

- Thought experiment
- Single Hydrogen-3 atom
- 12.32 years half-life
- 100 runs




Half-Life Experimental Function
Proportion of Unstable Isotopes Remaining
Half-Lives
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1
2
3
4
5

MATLAB Code

"halfLifeMLE" Main program

```
global bern timesVect1 proportionsVector1 countsVector;
opts = optimset ('DerivativeCheck', 'off','Display','off','TolX',1e-6, 'TolFun',1e-6,'Diagnostics', ...
    'off','MaxIter',200,'LargeScale','off');
bern = 99;
timesVect1 = (1/200)*[2, 19, 43, 74, 103, 172, 205, 340, 449, 662, 762, 863, 1151]';
countsVector = [98, 90, 80, 70, 60, 50, 40, 30, 20, 15, 10, 5, 1]';
proportionsVector1 = (1/bern)*[99, 90, 80, 70, 60, 50, 40, 30, 20, 15, 10, 5, 1]';
starting_estimatedParam1 = rand(2, 1);
lower_param1 = (-1)*ones(2, 1);
upper_param1 = 2*ones(2, 1);
while 1
[estimatedParam1, likely2, exited2] = fmincon ('halfLife_mle',starting_estimatedParam1, [], [], [],
[],lower_param1,upper_param1,[],opts);
```

Code inspired by:

Myung, Jae (2003) "Tutorial on Maximum Likelihood Estimation"
Journal of Mathematical Psychology 47, 90-100.

Conclusions

-Students involved in the PBL they report being enthusiastic, enjoy working with others
-Students have a better understanding of the subject matter