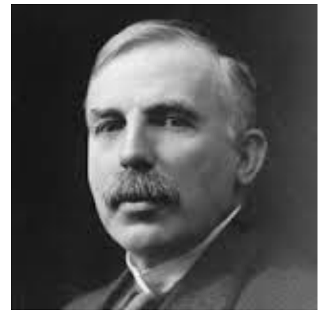
Rutherford Experiment – a pHet Inquiry



Materials needed: computer, ruler, protractor

Prelab – Read your physics text – Rutherford's gold foil experiment on page #412.
In 1910 when this experiment was first conducted, negative electrons had already been discovered but no other atomic building building particles were known. (protons & neutrons undiscovered). Since atoms were known to be neutral in charge, a positive particle was predicted to exist.

Procedure:
• Google and open 'phet' simulations → physics → alphabetical find 'Rutherford scattering'.

• You will toggle between 'Rutherford atom' and 'plum pudding' atom.

Note: The popular model before Rutherford's famous experiment was called the 'plum pudding' model. This model predicted positive charges spread throughout the atom (red) with some negative electrons (blue) scattered throughout like raisins (in a plum pudding). Alpha particles were spontaneously emitted from a radioactive polonium sample so he channeled these through a lead tunnel towards a target.

Part A: A1.10 – Draw conclusions based on results/research

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Fill-in-the-blank

Choose the Plum Pudding Model. In this simulation you must turn on the alpha particle 'gun'. This is a cartoon representation. There wasn't a 'gun'! This shows the results predicted by the Plum Pudding model. Are the alpha particles going straight through? (yes or no) __________________

→ TURN OFF THE GUN

1. Choose the Rutherford model: The alpha particles were fired at a very thin piece of ________________. What is the large unmoving mass of red & silver balls in the middle of the screen? ______________________________

2. → TURN ON THE GUN . Although Rutherford could not see inside the atom, he did observe particles behaving like this. (A fluorescent screen lit up when the alpha particles struck it. The screen curved around the whole foil sample).

3. Before they enter the screen, the alpha particles were travelling in a straight line.

Predict: If no net force is acting on alpha particles, describe their observed path:

____

What do you observe happening to the alpha particles' path?

____

Newton would say there must be a _________________ present.

4. Are the positive alpha particles being repelled or attracted to the mass in centre of screen?

____

Knowing the "Law of Electrostatic Charges", you can predict this mass in centre of screen must have a _____________________ charge (+ve or –ve)

5. What do you think an alpha particle really is? Explain your answer.

____

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Part B: Research / Think like a scientist (qualitative)

D2.3: analyze/solve problems involving electric force.

6. Research why radioactive material is dangerous to living things. I suggest you find a reliable, scientific site on the internet to help you here. Your brief answer should fit in the space below. Please write in your own words to demonstrate understanding (vs. 'copying').

Site used: www.______________________________ (2)

7. Explore the Rutherford model some more. Find variables that you can change (sliders are available). Change the variables (one at a time – good science!) and observe what happens. From this, provide a plausible explanation knowing what you know about physics so far. Record all in the chart below. Hint: clicking on 'show traces' might help you 'see' better. (3)

Variable changed	Observation	Possible explanation for this result

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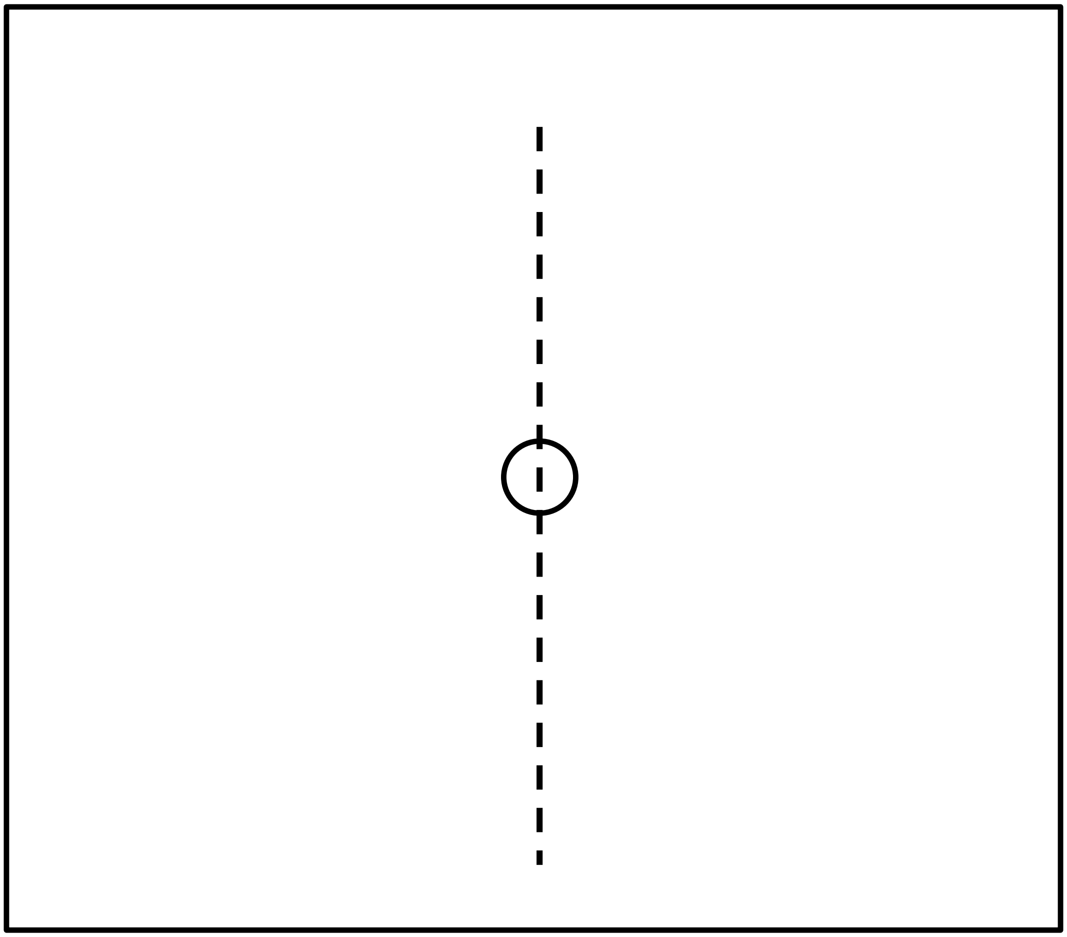
Part C: Research / Think like a scientist (quantitative)

D2.5: conduct a computer simulation to examine particle behavior in a field.

On the next page is a rectangle – this represents the screen on your pHet simulation. Look carefully at the computer screen. At the very edges of the rectangle you can see one blue electron orbiting. It's path is designated by a dashed line – you will only see small bits of it at the corners of your rectangle. This is the 1^{st} electron orbit.

8. Draw in the bits of the electron orbit that you can see. Use a dashed line just like simulation. Label this line appropriately. Also notice a vertical line. This represents the **centre line.**

Alpha Particle Deflection Paths



9. Click on **SHOW TRACES** and use **PAUSE** and **STOP** controls to visualize complete tracks as alpha particles are deflected. You are going to carefully choose 4 different particles. You want to find alpha particles that are 3 cm, 2 cm, 1 cm and 0.5 cm from this centre line. Pause the action when you have a particle of interest.

10. Once you have one, pause the screen and as accurately as possible, draw this path on your '**alpha particle deflection paths**' diagram above. Keep the action paused.

11. Now take out your ruler and protractor and measure carefully **from the <u>screen</u>** to complete the first 2 rows in the chart on the next page ('distance to centre line' and 'angle change').

note: Chart and deflection path diagram must be complete for full marks.

Alpha Particle Paths				
Distance to centre line	3 cm	2 cm	1 cm	0.5 cm
Angle of deviation from original path				
Distance from centre line squared				
1/(distance square)				
Relative force ratio				

12. Complete the calculations for distance squared and 1/(distance squared).
13. To get the 'relative force', divide each 1/(distance squared) by 0.1111   Although the REAL distances are much smaller, the relative force number ration will be valid.

14. Describe the trends you see:

a) What happens to the angle of deviation as you get closer to the centre line? (2)

b) What happens to the relative force ration as you get closer to the centre line? (2)

c) Can you make sense of these trends using Coulomb's Law and Newton's 2^{nd} law? (1)