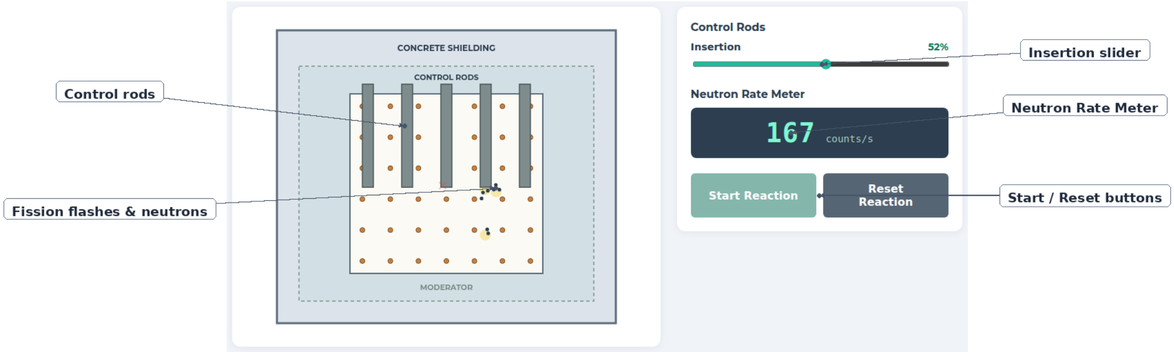
# Controlling a Nuclear Chain Reaction

## Control Rod Insertion and the Neutron Rate

*Aim:*

You are investigating how control rod insertion affects the neutron rate in the reactor core, and whether there is a rod setting that keeps the chain reaction steady.




*Prediction:*

With the rods fully inserted (100%) the meter reads background. Predict what will happen to the neutron rate if you withdraw the rods to 0%: will it rise, fall, or stay the same?

Prediction: ......................................................

Test it in the simulation.

*Method:*

1. Press Reset Reaction, set the Insertion slider to 0%, then press Start Reaction and let the meter climb towards its maximum.
2. Set the rods to 20%. Wait about ten seconds, then read the Neutron Rate Meter. Record the insertion, the rate, and whether it is rising, steady or falling in your results table, pressing Add Row for each new row.
3. Repeat for 40%, 60%, 80% and 100%.
4. Using your table, narrow down the boundary between settings that make the rate rise and settings that make it fall. Test insertions in smaller steps (5%, then 1%) until you find a setting where the meter holds steady, within its normal flicker, for at least 20 seconds. Record this setting in your table.
5. Press Reset Reaction and start again from a low rate at your steady setting, to check the reading is repeatable.

*Results:*

| # | Rod insertion (%) | Neutron rate (counts/s) | Rising / steady / falling |
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*Analysis:*

Look down your results table. Where is the boundary between rod settings that make the neutron rate rise and settings that make it fall?

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Set the rods a few percent below your steady setting. Starting from a low rate, record the meter reading every 5 seconds for 30 seconds in the table below.

| time (s) | neutron rate (counts/s) |
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Does the rate go up by the same amount each time, or by the same factor?

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Now set the rods a few percent above your steady setting and, starting from a high rate, take readings every 5 seconds in the table below.

| time (s) | neutron rate (counts/s) |
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What pattern do your numbers follow on the way down?

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*Explaining why:*

This meter stops at its top value, but a real reactor's fission rate would not. Using the pattern you found above, describe what would happen to the energy released each second if the rate kept growing, and explain why that kind of growth is dangerous.

Each fission releases energy and sets free two or three more neutrons. Why does 'same factor' growth run away so much faster than 'same amount' growth?

Insert the rods to 100% and watch where the meter settles. Why does it not fall all the way to zero?

In an emergency a reactor drops its control rods fully in. Watch the diagram at 100% insertion and look at what happens to neutrons that hit a rod. Use this to explain why full insertion always shuts the chain reaction down, whatever the rate was before.