Introduction:

This experiment explores the way in which the *intensity* of radiation decreases as you move away from the source.

Learning Outcomes:

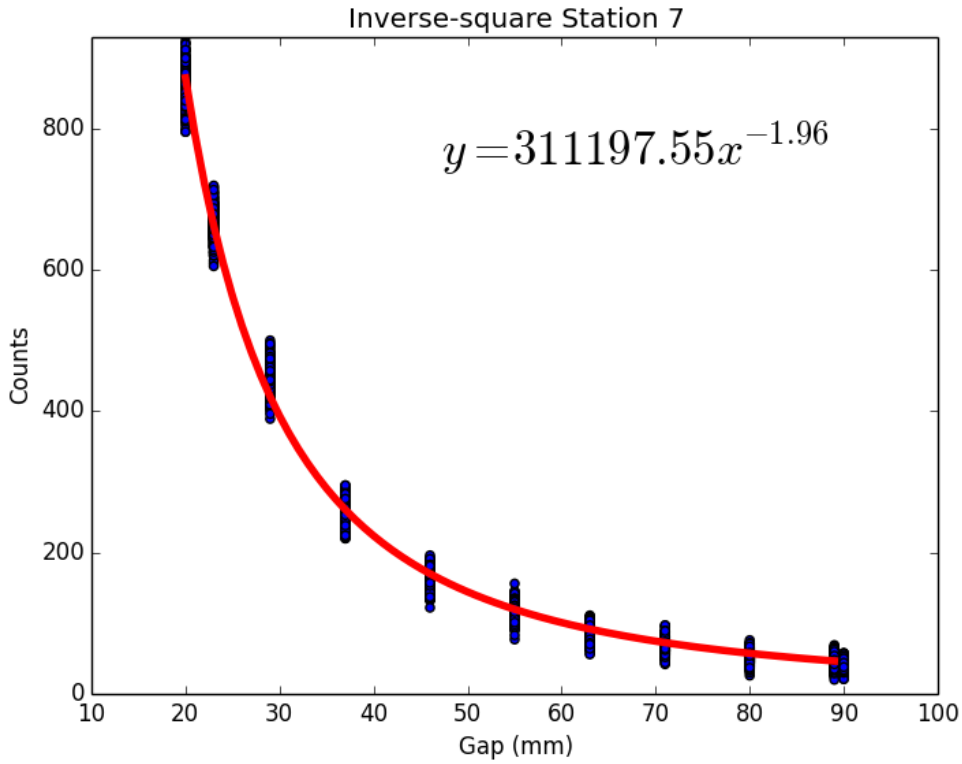
- Students will appreciate the rapid decrease in radiation intensity with distance, and how this allows a safe distance to be established around nuclear accidents.
- Students will understand what is meant by the "inverse-square" law and how it applies to more than just nuclear radiation.

Experiment Summary:

- Students will remotely access a Geiger counter placed near a radioactive source. The distance of the detector from the source can be varied.
- Students take measurements of the radiation counts at various distances from the source.
- Students make a plot of radiation counts vs distance and are guided to an understanding of the inverse-square law; that is, that intensity decreases as the distance squared.

Expected Results:

- At the shortest distance the number of counts/second is generally high (> 200 for most stations).
- This count-rate diminishes rapidly as the gap between the source and detector is increased.
- By plotting counts/second vs distance for at least 6 well-spaced distances, students should see a nice $1/r^2$ graph.
- The most important gaps to measure are the smaller ones, since here the counts are changing most rapidly.
- Students should see from their graphs that doubling the distance reduces the counts by a factor of 4 (approximately).
- The figure below shows some actual data taken from Inverse-square station 7. Data were recorded for a duration of 3 minutes at each gap. The red line shows a power law fit to the data, and the fit parameters are included in the plot.



Sample data recorded on Inverse-square station 7.

Answers to Evaluate Questions:

1. The counts decrease by a factor of 4.
2. The number of counts would decrease to about 250.
3. The number of counts would decrease to about 100.
4. You need to be 3 times further away than you are to reduce the counts by a factor of 9. So, move to 30 km.
5. Mars is quite a bit further from the sun than the earth is. The suns radiation spreads out just like any other radiation so its intensity decreases with distance (as $1/r^2$). So to get the same power, the solar panels on Mars need to be much larger.
6. As the solar panel on the space probe gets further away from the sun it will generate less power as the solar intensity decreases. The power it generates will decrease as the distance squared. The solar panel can be reduced in power by a factor of 100 and still keep the probe going. Solar intensity decreases by a factor of 100 if the distance increases by a factor of 10. So the probe will work at up to 10 times the sun-earth distance. That is, up to 1500 million km or 10 AU.
7. The space probe can make it to Saturn (9.5 AU) just!

Detailed Explanation:

- Anything that is emitted radially outwards and travels in straight lines will diminish in intensity as $1/r^2$.
- A constant total amount of radiation is emitted uniformly in all directions in space. This means that at a particular distance from the source, a constant amount of radiation is evenly distributed over the surface of a sphere with surface area $4 \pi r^2$. At greater distances you still have the same *total* amount of radiation, but it is distributed evenly over a larger and larger sphere. So, the intensity of the radiation at a given location (radiation/unit area) *decreases* as radial distance squared.

Technical notes on the experiment:

- Note, that the absolute value of the count rate is not really important; all that matters in this experiment is the *change* in counts when the distance is changed. The basic count rate at the shortest distance may vary for different sets of apparatus. This can sometimes be confusing for the students.
- There may be a delay of a couple of seconds when changing the distance before the change occurs and the count rate stabilises.
- Students need to enter their numbers manually in the spaces below the video feed for plotting. Numbers can be entered for plotting without actually doing the experiment.