WHAT HEISENBERG KNEW
STUDENT PAGES

DESCRIPTION

Werner Heisenberg (1901–1976) was one of the most important physicists in the creation of quantum mechanics. In 1927, he proposed the uncertainty principle. It stated that pairs of complementary variables in physics had minimal measurement uncertainties based on a relationship with each other: less uncertainty in one inevitably yields greater uncertainty in the other, no matter how sophisticated the measurement technique. Your task is to determine if the experimental data provided represents complementary variables by testing for an inverse relationship.

What do we know?

- These data represent the uncertainty in position and momentum as determined by a diffraction experiment in 2001. See Figure 1 below.

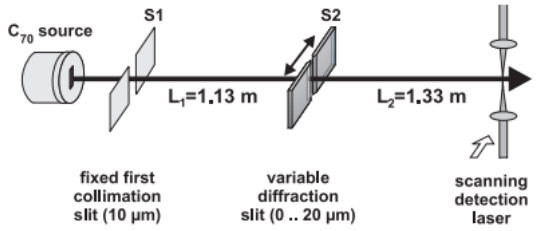

Figure 1: *Experimental setup made by Nairz, Arndt, and Zeilinger, 2001,* [*https://arxiv.org/abs/quant-ph/0105061*](https://arxiv.org/abs/quant-ph/0105061).

- The uncertainty in position is determined using the slit width.
- The uncertainty in momentum is determined using the width of the central maximum.
- The steps for linearizing graphed data

What do we need?

- **Data Table A: Complementary Variables Momentum (p) and Position (x)**

Uncertainty in Position, Δx (micrometers)	**Uncertainty in Momentum, Δp (x 10^{-27} kg-m/s)**	**Reciprocal 1/Δx (1/ µm)**
0.09	9.6	
0.28	2.8	
0.46	1.3	
0.65	1.0	
1.36	0.5	
2.52	0.3	

- Graph paper or a graphing program

What do we do?

- **Plot** Δp vs. Δx.
- **Describe** the shape of the graph.
- **Make a claim** about what happens to Δx when Δp increases.

- **Determine** the necessary steps to linearize the graph.
- **Determine** the mathematical model described by the linearized graph.
- **Make a claim** about the relationship between your mathematical model and Heisenberg's uncertainty principle.
- Be prepared to share your claims, evidence and reasoning to the class.