

Section 8: Measurements

1. Propagation of Error

The length and width of a rectangular plate are measured to be $L = (15.3 \pm 0.1)$ cm and $W = (8.4 \pm 0.1)$ cm. Calculate the area of the plate and its absolute uncertainty.

2. Propagation of Error

The radius of a sphere is measured to be $r = (6.20 \pm 0.05)$ cm. Calculate the volume of the sphere and its associated uncertainty.

3. Statistics

Ten measurements of the time period of a pendulum are (in seconds): 2.01, 1.99, 2.02, 2.00, 1.98, 2.01, 2.03, 1.99, 2.00, 2.02. Calculate the mean value and the standard deviation of these measurements.

4. Relative Uncertainty

A car's speedometer has a 5% uncertainty. If it reads 60 km/h, what is the range of the car's actual speed?

5. Combined Uncertainty

The resistance R is calculated using Ohm's Law, $R = V/I$. If the voltage is measured as $V = (10.0 \pm 0.2)$ V and the current as $I = (2.00 \pm 0.05)$ A, what is the calculated resistance and its uncertainty?

6. Error Analysis

The mass of the Earth M can be estimated using the formula $M = \frac{gR^2}{G}$. Calculate the percentage error in the mass of the Earth if the error in measuring g is 1% and the error in measuring R is 0.5%. (Assume G is known exactly).

7. Percentage Calculation

A measurement of time is recorded as $t = 5.45 \pm 0.22$ seconds. What is the percentage uncertainty of this measurement?

8. Instrument Precision

A digital thermometer reads 25.4°C. Assuming the uncertainty is half the value of the last digit, what is the absolute uncertainty of this measurement?

9. Standard Deviation

Eleven students received the following scores on a test: 88, 92, 79, 85, 95, 81, 86, 90, 83, 77, 89. What is the standard deviation of these test scores?

10. Experimental Gravity

An apple is dropped from a height of $h = 10.0 \pm 0.1$ meters. The time it takes to fall is measured as $t = 1.42 \pm 0.05$ seconds. Using the formula $g = 2h/t^2$, calculate the acceleration due to gravity and its uncertainty from this experiment.