Pakistan School
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Calculating uncertainty in the final result Class 11

Objective

- Students will be able to differentiate:
- Power of a Quantity
- Average for many measurements
- Uncertainty in a Timing

Starter:Revision

- For Addition and Subtraction Rule :
- The uncertainties are added

- For Product and Quotient Rule :
- The Percentage uncertainties are added.

For Power of a Quantity

- In case of power factor, we multiply the %age uncertainty by the power e.g if we calculate the volume of the sphere by using the formula $V=4/3\pi r^3$, the %age uncertainty in V=3 x % age uncertainty in radius r
- If the radius of the sphere is measured as 2.25cm by a vernier caliper with least count 0.01cm, then the radius with absolute uncertainty 0.01cm is r = 2.25 ± 0.01cm
- %age uncertainty in r =(0.01/2.25)x(100/100) = $\frac{0.01}{2.25} X \frac{100}{100}$ = 0.4%
- The total %age uncertainty in V= 3 x 0.4 %= 1.2%
- Thus the volume is $V=4/3\pi r^3$= 4/3 x3.14x $(2.25)^3$ = 47.7cm^3 with 1.2%uncertainty
- 1.2% of 47.7 is (47.7 x(1.2/100))= ($\frac{47.7}{} X \frac{1.2}{100}$) = ± 0.57$cm^3$= 0.6$cm^3$
- Hence Volume =(47.7± 0.6)cm^3

For Uncertainty in the Average Value of Many Measurements

(1.51-1.50) =0.01

(1.51-1.51) =0.00

(1.52-1.51) =0.01

Find the average value of the measured values.

1. Find the deviation of each measured value from the average value.
2. The mean deviation is the uncertainty in the average value.

For example, we take three readings to be measured in cm as

$X_1=1.50$, $X_2=1.51$, $X_3=1.52$ and their average

$$=\frac{1.50+1.51+1.52}{3} \quad =1.51$$

The deviation of each reading from average is 0.01, 0.00, 0.01

$$\text{Mean of deviation} \quad =\frac{0.01+0+0.01}{3}$$

$$=0.0067\text{mm}$$

Thus the uncertainty in the mean 1.51 mm is written as 1.51 ± 0.0067mm

For the Uncertainty in a Timing Experiments

The uncertainty in the time period of a vibrating body is found by dividing the least count of timing device by the number of vibrations e.g the time of 30 vibrations of a simple pendulum recorded by a stop watch having least count 0.1 second is 54.6s,

Suppose a simple pendulum completes 30 vibrations in 54.6 seconds then absolute error in time is 0.1sec.

The period T of one Vibration=54.6/30= 1.82s

with uncertainty 0.1/30=0.003s

Thus ,the time period T is written as 1.82±0.003s.

It is notable that we should count a large number of swings to reduce timing uncertainty.

Closure: Plenary: Questions

- Q. “Multiply the %age uncertainty by the power” is Rule for?
- Ans: Power of a Quantity
- Q. “Mean deviation is the uncertainty in the average value” is the rule for ?
- Ans: Uncertainty in the Average Value of Many Measurements
- Q. “Dividing the least count of timing device by the number of vibrations” is the Rule for?
- Ans: Uncertainty in a Timing

Home Work

- Apply least 2 Uncertainty in Every day life
- Or
- Make a chart about different uncertainty

For Uncertainty in the Average Value of Many Measurements

(1.21-1.20)=0.01
(1.22-1.21)= 0.01
(1.23-1.21)=0.02
(1.19-1.21)= 0.02
(1.22-1.21)= 0.01
(1.21-1.21)=0.00

Find the average value of the measured values.

1. Find the deviation of each measured value from the average value.
2. The mean deviation is the uncertainty in the average value.

For example, we take six readings of the [illegible] to measure the diameter of the wire in mm as 1.20 1.2[illegible] 1.21 and their average

$$=\frac{1.20+1.22+1.23+1.19+1.22+1.21}{6} = 1.21$$

The deviation of each reading from average is 0.01,0.01,0.02,0.02,0.01,0.

Mean of deviation

$$=\frac{0.01+0.01+0.02+0.02+0.01+0}{6}$$

$$=0.01\text{mm}$$

Thus the uncertainty in the mean diameter 1.21mm is written as $1.21 \pm 0.01\text{mm}$