# 2.6 Probability and uncertainty

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

**KEY WORDS** expanded uncertainty • propagation of uncertainty

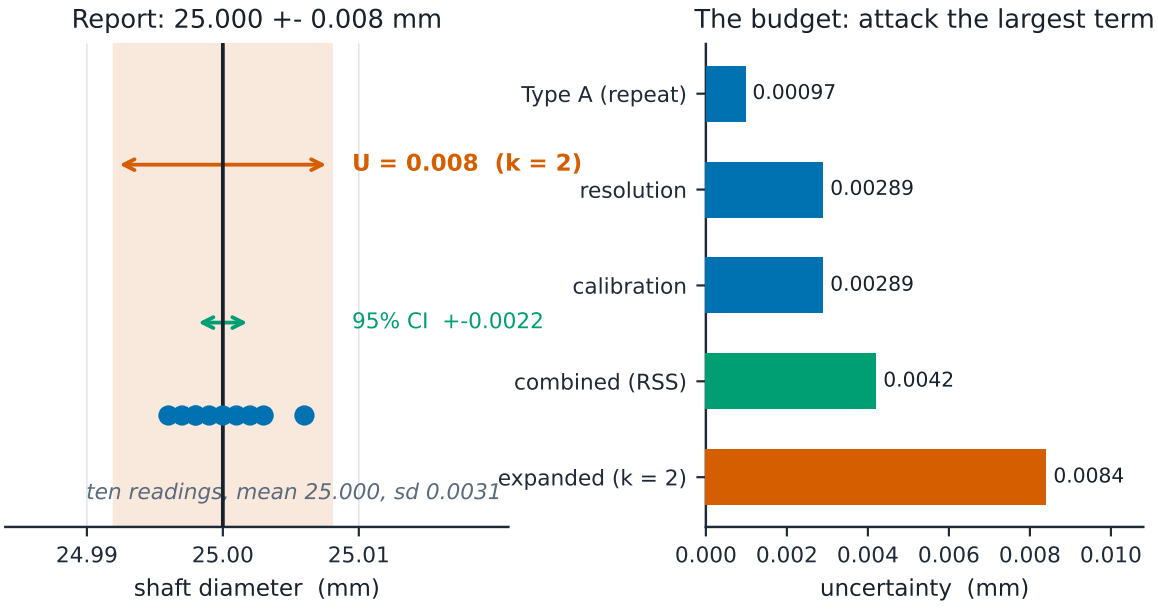
## Objective

Build an uncertainty budget, expand it, and propagate it into a computed result.

## 1 Key knowledge and worked examples

### ■ Budget, expansion, propagation

Type A $s/\sqrt{n}$; Type B rectangular $a/\sqrt{3}$, resolution $q/\sqrt{12}$; combine by RSS; $U = ku_c$ with $k = 2$; propagate by the partial-derivative rule, RSS for independent inputs.




*The interval travels with the number*

### ■ Worked example. The pivot shaft

Mean 25.000, sd 0.0031, se 0.00097; budget 0.00097 / 0.00289 / 0.00289 - $u_c = 0.0042$, $U = 0.008$; area $490.9 \pm 0.3$ mm2 ✓.



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## 2 Practice

Eight readings of a link length (mm): 18.4, 18.6, 18.5, 18.3, 18.7, 18.5, 18.4, 18.6. Resolution 0.02 mm; calibration certificate ±0.01 mm. t(7, 95%) = 2.365.

**2.1** The mean, sd and standard error (four decimals). [3]

**2.2** The two Type B terms (four decimals). [2]

**2.3** $u_c$ and $U$ ($k = 2$), and the report line. Which term dominates this time? [4]

**2.4** The link's cross-section $A = \pi d^2/4$ at the mean diameter: $A$ (one decimal) and its propagated interval (one decimal). [5]



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## Solutions

**2.1**

- Mean 18.5000 mm; sd 0.1309 mm.
- se $= 0.1309/\sqrt{8} = 0.0463$ mm.

**2.2**

- Resolution $0.02/\sqrt{12} = 0.0058$; calibration $0.01/\sqrt{3} = 0.0058$ mm.

**2.3**

- $u_c = \sqrt{0.0463^2 + 0.0058^2 + 0.0058^2} = 0.047$ mm; $U = 0.094$ mm.
- Report $18.50 \pm 0.09$ mm ($k = 2$) - here Type A dominates: more readings WOULD help (contrast the shaft case).

**2.4**

- $A = \pi(18.5)^2/4 = 268.8$ mm2.
- $u_A = \frac{\pi d}{2} u_c = \frac{\pi \times 18.5}{2}(0.047) = 1.367$ mm2; report $268.8 \pm 2.7$ mm2 ($k = 2$).



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