



醫療儀器量測之基本原理
Biomedical Instrumentation and
Measurement

Chapter 3

Biomedical Instrumentation and Measurement

□ Significant figures(數字)

- ❖ 量測到 0.60與 0.6相同意義嗎?
- ❖ 量測到 16加侖, 是15與17的平均數嗎?
- ❖ 若分別量測到16.1加侖與15.9加侖, 如何表示?
- ❖ 當讀值為 $100 \pm 5\%$ (Accuracy)加侖時, 其正確的值界在 $100-5\% \sim 100+5\%$ 與 $95 \sim 105$ 間

□ Last digit bobble

19.99
Most significant digit ● ———— ↑ ↑ ———— ● Least significant digit

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- The instrument reads from 00.00 to 19.99V, with an accuracy of $\pm 1\%$.
- Digital voltmeters typically have a ± 1 digit error in least significant position.
 - ❖ The last digit bobble problem mean that a reading of 15.00V
 - ☛ The reading of 15.00V could represent any value between 14.99 and 15.01.
 - ☛ In addition, the error of 1% means that the actual voltage could be $15.00 \pm 1\%$. The actual voltage could be 14.85 to 15.15

If both errors are minus

15.00V	15.00V
-0.01V	+0.01V
-0.15V	+0.15V
<hr style="width: 100%;"/>	<hr style="width: 100%;"/>
14.84V	15.16V
Worst case	Worst case

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- ❑ Significant figure errors are propagated in calculations
 - ❖ The number of significant figures is not improved(改進) by combing the numbers with other numbers

$$\begin{array}{r} 15.6\hat{5} \\ \times 0.02\hat{5} \\ \hline \overset{\wedge}{7}\overset{\wedge}{8}\overset{\wedge}{2}\overset{\wedge}{5} \\ 313\hat{0} \\ 000\hat{0} \\ 000\hat{0} \\ \hline \overset{\wedge}{0}\overset{\wedge}{.}\overset{\wedge}{3}\overset{\wedge}{9}\overset{\wedge}{1}\overset{\wedge}{2}\overset{\wedge}{5} \end{array}$$

- ☛ Only the 3 and one of the leading zeros are significant
- ☛ May better list this value as 0.4W

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□ Scientific notation(標記)

- ❖ Simple arithmetic shorthand
- ❖ Allow the matter to deal with very large or very small numbers using only a few digits between 1 and 10, and power-of-ten exponents

$$\text{Numbers} \cdot \uparrow \text{n.ij} \times 10^{\text{exponent}} \leftarrow \text{Base-10}$$

$$\text{Age}=47 \text{ years}=4.7 \times 10^1 \text{ years}$$

☛ The exponent is negative $10^{-x} = \frac{1}{10^x}$