IGCSE Physics Worksheet

Topic: Length, Time, and Measurement Techniques / 長度、時間與測量技巧

Reading Passage / 閱讀文章

In physics, accurate measurement is essential because even small errors can affect the results of an experiment. Three of the most fundamental quantities measured in science are length, time, and mass, but this passage focuses on length and time, along with the techniques used to measure them precisely.

Measuring Length

Length is the distance between two points. It can be measured using different instruments depending on the required accuracy. A ruler or metre rule is commonly used for everyday measurements, but it has a limited precision of about ±1 mm. For more accurate measurements, a vernier caliper or micrometer screw gauge is used.

A vernier caliper can measure internal diameters, external diameters, and depths with a precision of ±0.1 mm. It uses a main scale and a vernier scale; the reading is found by adding the two scales together.

A micrometer screw gauge is even more precise, with a typical precision of ±0.01 mm. It works using a rotating thimble and a screw mechanism. The reading is obtained by adding the sleeve scale and the thimble scale.

To reduce errors when measuring length, students should avoid parallax error, which occurs when the eye is not directly in line with the scale. Repeating measurements and taking an average also improves accuracy.

Measuring Time

Time is measured using clocks, stopwatches, or electronic timers. A digital stopwatch is commonly used in school laboratories and can measure to an accuracy of 0.01 s. However, human reaction time introduces uncertainty when starting or stopping the timer.

To reduce reaction-time error, experiments often involve timing many oscillations of a pendulum or several cycles of motion, then dividing by the number of cycles to find the average time for one cycle.

Measurement Techniques

Good measurement technique includes choosing the correct instrument, checking for zero error, avoiding parallax, repeating measurements, recording units clearly, and estimating uncertainties.

Zero error occurs when an instrument does not read zero even when nothing is being measured. This value must be corrected in all readings.

在物理學中，準確的測量非常重要，因為即使是微小的誤差也會影響實驗結果。科學中最基本的三個測量量是長度、時間和質量，但本文章集中於長度與時間，以及如何準確地測量它們。

測量長度

長度是兩點之間的距離。根據所需的精確度，可以使用不同的儀器。直尺或米尺常用於一般測量，但其精度只有約 ±1 mm。若需要更高精度，可使用游標卡尺或螺旋測微器。

游標卡尺可測量內徑、外徑和深度，精度約為 ±0.1 mm。它利用主尺和游標尺，讀數為兩者的總和。

螺旋測微器的精度更高，通常可達 ±0.01 mm。它利用旋轉套筒與螺旋機構進行測量，讀數由套筒刻度與旋鈕刻度相加而得。

為減少測量長度時的誤差，學生應避免視差誤差，即眼睛沒有與刻度線垂直對齊時產生的誤差。重複測量並取平均值也能提高準確度。

測量時間

時間可利用時鐘、秒錶或電子計時器測量。數碼秒錶常用於學校實驗室，精度可達 0.01 秒。然而，人的反應時間會在開始或停止計時時造成不確定性。

為減少反應時間誤差，實驗通常會測量多次擺動或多個循環的總時間，再除以次數以求得平均單次時間。

測量技巧

良好的測量技巧包括：選擇合適的儀器、檢查零誤差、避免視差、重複測量、清楚記錄單位，以及估計不確定度。

零誤差是指儀器在未測量任何物體時並未顯示零。此誤差必須在所有讀數中修正。

Questions / 問題

Section A: Short Questions / A 區：短答題

1. Define length. / 定義長度。

2. State one advantage of using a vernier caliper instead of a ruler. / 說出使用游標卡尺比使用直尺的一個優點。

3. Explain what parallax error is. / 解釋什麼是視差誤差。

4. Why is a micrometer screw gauge more precise than a ruler? / 為何螺旋測微器比直尺更精確？

5. What is zero error? / 什麼是零誤差？

Section B: Structured Questions / B 區：結構化題目

6. A student measures a rod three times: 12.4 cm, 12.5 cm, 12.4 cm.

(a) Calculate the average length. / 計算平均長度。

(b) Explain why repeating measurements is useful. / 解釋為何重複測量有用。

7. A micrometer shows 5.0 mm on the sleeve and 0.28 mm on the thimble.

(a) Calculate the total reading. / 計算總讀數。

(b) If zero error is +0.02 mm, give the corrected reading. / 若零誤差為 +0.02 mm，求修正後讀數。

8. A stopwatch records 32.6 s for 20 swings of a pendulum.

(a) Calculate the time for one swing. / 計算一次擺動的時間。

(b) Explain why timing many swings improves accuracy. / 解釋為何測量多次擺動能提高準確度。

Section C: Extended Response / C 區：長答題

9. Describe how to measure the diameter of a small marble accurately. / 詳細描述如何準確測量一顆小玻璃珠的直徑。

Answer Key / 答案

Section A

1. Length is the distance between two points. / 長度是兩點之間的距離。

2. A vernier caliper has higher precision than a ruler. / 游標卡尺的精度比直尺高。

3. Parallax error occurs when the scale is viewed from an angle. / 視差誤差是指從斜角觀看刻度時產生的誤差。

4. A micrometer has finer scale divisions (±0.01 mm). / 螺旋測微器的刻度更細（±0.01 mm）。

5. Zero error is when an instrument does not read zero at rest. / 零誤差是儀器在未測量時不顯示零。

Section B

6(a) Average = (12.4 + 12.5 + 12.4) / 3 = 12.43 cm. / 平均值 = 12.43 cm。

6(b) Repeating reduces random errors and improves accuracy. / 重複測量可減少隨機誤差，提高準確度。

7(a) 5.00 + 0.28 = 5.28 mm. / 總讀數 = 5.28 mm。

7(b) 5.28 - 0.02 = 5.26 mm. / 修正後讀數 = 5.26 mm。

8(a) 32.6 / 20 = 1.63 s. / 一次擺動時間 = 1.63 秒。

8(b) Timing many swings reduces reaction-time error. / 測量多次擺動可減少反應時間誤差。

Section C

9. Use a vernier caliper or micrometer, measure several times at different angles, avoid parallax, check zero error, and take the average. / 使用游標卡尺或螺旋測微器，在不同角度多次測量，避免視差，檢查零誤差，並取平均值。