

EXPERIMENTAL WORK
IN
PHYSICS
(SECONDARY 4-5)

中學物理科
實驗補充資料
(中四至中五適用)



香港教育署課程發展處
數學、科學及電腦教育組

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3. APPENDIX II: NOTES ON UNITS

Throughout this course the International System of Units (SI) will be used. The use of the SI system provides a simple and rational development of units. Among its advantages are the separation of the measures of weight (in N) and mass (in kg) and the unification provided by the use of joule (J) for all forms of energy. The use of g as 10 N kg^{-1} reinforces the distinction between mass and weight.

For teachers' ease of reference, some guidelines on the use of SI units⁽¹⁾ are given below.

A. SI base units

The international system is based on a choice of seven well-defined units which by convention are regarded as dimensionally independent: the metre, the kilogram, the second, the ampere, the kelvin, the mole, and the candela.

Basic physical quantity	Unit	
	Name	Symbol
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

B. SI derived units

Derived units are expressed algebraically in terms of base units by means of the mathematical symbols of multiplication and division. Examples of SI derived units:

Physical quantity	SI derived unit		Other commonly used units
	Name	Symbol	
acceleration	metre per second squared	m s^{-2}	
density	kilogram per cubic metre	kg m^{-3}	g cm^{-3}
electric charge	coulomb	C	
electromotive force	volt	V	
energy	joule	J	
force	newton	N	
frequency	hertz	Hz	
moment	newton metre	N m	
momentum	kilogram metre per second	kg m s^{-1}	
power	watt	W	kW
pressure	pascal	Pa	kPa, N m^{-2}
resistance	ohm	Ω	
specific heat capacity	joule per kilogram kelvin	$\text{J kg}^{-1} \text{K}^{-1}$	
velocity	metre per second	m s^{-1}	
voltage	volt	V	kV
work	joule	J	

⁽¹⁾

For detailed guidance on units and symbols, teachers may wish to refer to

1. Association for Science Education. (1981), *SI Units, Signs, Symbols & Abbreviations*, UK: ASE.
2. 杜荷聰、王啓堯、袁楠(1986), 《高等學校教學參考書—物理量與單位》, 中國計量出版社。

C. SI prefixes

The prefixes and symbols of prefixes are used to form the names and symbols of the decimal multiples and sub-multiples of SI units.

Examples of prefixes:

Prefix	Symbol	Multiple
giga	G	10^9
mega	M	10^6
kilo	k	10^3
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}

D. Printing and writing of symbols for units

- Units are only printed in roman (upright) type.
e.g. kg, m, N
- Unit symbols are unaltered in the plural.
e.g. 1 m, 10 m
- Unit symbols are not followed by a full stop.
- Symbols for units are not written with capital initial letters.
e.g. kg (kilogram), m (metre), s (second)
If, however, the unit is named after a person, the first letter of the symbol for the unit is in upper case.
e.g. N (newton), W (watt), Hz (hertz)
A very special case is the litre where both L and l are used, as the lower case symbol can lead to confusion when certain typefaces are used.
- Symbols for physical quantities are printed with a spacing between the magnitude and the unit. When two or more symbols are combined to indicate a derived unit, a space is inserted between them.
e.g. 12 m s^{-1} but not 12ms^{-1} or 12 ms^{-1}
 24 N m but not 24Nm or 24 Nm
- The solidus must not be repeated on the same line unless ambiguity is avoided by parentheses. In complicated cases negative exponents or parentheses are preferred.
e.g. 3 m/s^2 but not 3 m/s/s
 3 J/(kg K) is preferred to 3 J/kg K
- Prefix symbols are printed in roman (upright) type without spacing between the prefix symbol and the unit symbol.
e.g. 3 mA, 3 km, 3 M Ω
- Prefixes should not be used in combination.
e.g. $3 \mu\text{A}$ but not 3 mA

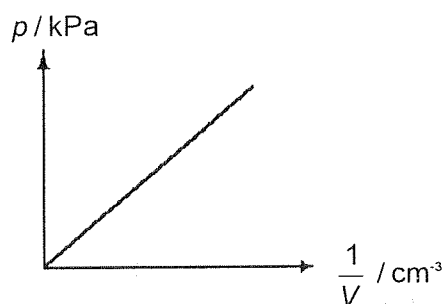
9. In compound expressions, confusion is less likely to arise if the use of a prefix is restricted to the numerator.
e.g. 3 km/s is preferable to 3 m/ms
10. Units written in full do not have capital initial letters, even when they commemorate a person.
e.g. 5 N (5 newtons), 50 Hz (50 hertz)

E. Printing and writing of symbols for physical quantities

1. The symbols for physical quantities are letters of the Latin and Greek alphabet, printed in *italic (sloping)* type to distinguish them from symbols for units which are always printed in roman (upright) type. For example the symbol for mass is usually printed in *italics* as '*m*', where the symbol for the unit of length 'metre' is printed upright as 'm'.
2. Symbols for some quantities are capital letters and for others lower case letters, e.g. *m* for mass, *v* for velocity, *V* for potential difference and *F* for force.
3. Symbols for vector quantities may be printed in **bold face italic** type when it is desired to draw attention to their vector nature. Sometimes, arrows are added to avoid confusion.
e.g. ***$\vec{F}$*** (or ***$\vec{F}$***) for force, ***$\vec{v}$*** (or ***$\vec{v}$***) for velocity, and ***$\vec{a}$*** (or ***$\vec{a}$***) for acceleration.
4. A symbol for a quantity represents both its magnitude and its units.
e.g. *m* = 5 kg, *F* = 10 N, and *V* = 7 V.
5. As graphs deal with pure numbers only, so the axes are labeled as '*R/Ω*', '*V/cm³*', '*p/kPa*' etc. where the solidus means 'divided by' (i.e. the physical quantity is divided by a unit, if *p* = 3 kPa then *p/kPa* is the pure number 3 only). The same applies to headings for tables. For example, in the experiment 'Investigation of the relationship between the pressure and the volume of air at constant temperature', the following table and graph are drawn:

Pressure of air <i>p/kPa</i>	Volume of air <i>V/cm³</i>	Reciprocal of volume $\frac{1}{V} / \text{cm}^{-3}$

Graph of *p* against $\frac{1}{V}$



4. APPENDIX III: NOTES ON COMMON CIRCUIT SYMBOLS

Graphical symbols are widely used in physics, particularly in the fields of current electricity and electronics. For reference, some of the common symbols used in school work are listed below.

	connecting wires crossing with no connection		transformer with ferromagnetic core
	junction of connecting wires		ammeter
	switch		voltmeter
	relay coil		galvanometer
	relay contact		loudspeaker
	cell		buzzer
	battery		motor
	earth		diode
	fuse		light dependent resistor
	filament lamp		light emitting diode
	fixed resistor		NOT gate
	potential divider		OR gate
	variable resistor		NOR gate
	thermistor		AND gate
	a.c. power supply		NAND gate

3. 附錄二 單位要點

本課程採用國際單位制，採用此制度使單位發展簡易而合理。其優點包括將重量的量度單位牛頓(N)及質量的量度單位千克(kg)分開，並用焦耳(J)使能量的量度單位統一。以 10 牛頓每千克(10 N kg^{-1})作為 g 之值可加強質量與重量的區別。

教師在採用國際單位制^[1]時，可參考以下指引。

A. 基本單位

國際單位制選定米、千克、秒、安培、開爾文、摩爾和坎德拉為七個基本單位，這七個基本單位在量綱上各自獨立。

基本物理量	單位	
	名稱	符號
長度	米	m
質量	千克	kg
時間	秒	s
電流	安培	A
溫度	開爾文	K
物質的量	摩爾	mol
發光強度	坎德拉	cd

B. 導出單位

導出單位乃根據基本單位，用乘除法處理後，以代數式表示。下表列出了一些導出單位的例子。

為對單位及符號有更深入的認識，教師可參考

1. 杜荷聰、王啓堯、袁楠(1986)，《高等學校教學參考書—物理量與單位》，中國計量出版社。
2. Association for Science Education. (1981), *SI Units, Signs, Symbols & Abbreviations*, UK: ASE.

物理量	導出單位		其它常用單位
	名稱	符號	
加速度	米每秒平方	m s^{-2}	g cm^{-3}
密度	千克每立方米	kg m^{-3}	
電荷	庫倫	C	
電動勢	伏特	V	
能量	焦耳	J	
力	牛頓	N	
頻率	赫茲	Hz	
力矩	牛頓米	N m	
動量	千克米每秒	kg m s^{-1}	
功率	瓦特	W	
壓強	帕斯卡	Pa	kW kPa, N m^{-2}
電阻	歐姆	Ω	
比熱容量	焦耳每千克開爾文	$\text{J kg}^{-1} \text{K}^{-1}$	
速度	米每秒	m s^{-1}	
電壓	伏特	V	kV
功	焦耳	J	

C. 詞頭

下列詞頭是用來表明各國際單位的十進倍數及分數。

詞頭	符號	倍數
吉	G	10^9
兆	M	10^6
千	k	10^3
分	d	10^{-1}
厘	c	10^{-2}
毫	m	10^{-3}
微	μ	10^{-6}
納	n	10^{-9}

D. 單位符號的書寫和印刷

1. 應用羅馬(正)體書寫各單位符號。

例：kg, m, N

2. 單位符號是沒有複數形式的。

例：1 m, 10 m

3. 單位符號後不加圓點。

4. 一般單位符號用小寫字母書寫，但當單位符號源於人名時，其第一個字母要用大寫字母書寫。

一般單位符號

例：kg (千克)， m (米)， s (秒)

當單位符號源於人名

例：N (牛頓)， W (瓦特)， Hz (赫茲)

(☆注意：為免與數字 1 混淆，升的符號有兩個：L 和 l。)

5. 量值的書寫與印刷，應在數值與單位之間留一間隔。如單位由兩個或以上符號組成，則符號間亦須留一間隔。

例：12 m s⁻¹ (✓) 不能寫成 12ms⁻¹ (✗) 亦不可寫成 12 ms⁻¹ (✗)

24 N m (✓) 不能寫成 24Nm (✗) 亦不可寫成 24 Nm (✗)

6. 用斜線表示除號時，在同一行內不得重複使用。當分母包括兩個或以上單位時，應於整個分母加上括號。

例：3 m/s² 不能寫成 3 m/s/s

3 J/(kg K) 不能寫成 3 J/kg K

7. 詞頭符號一律以羅馬(正)體書寫或印刷。詞頭符號與單位符號之間不留間隔。

例：3 mA, 3 km, 3 MΩ

8. 詞頭不應重複使用。

例：3 μA 不應寫成 3 mmA

9. 以代數式表示導出單位時，詞頭應置於分子，分母一般不帶詞頭。

例：3 km/s 不應寫成 3 m/ms

E. 物理量符號的書寫和印刷

1. 通常用拉丁字母或希臘字母表示量的符號，為免與單位符號混淆，量的符號應用斜體印刷。

例：用斜體 m 表示質量，而用羅馬(正)體 m 表示長度單位。

2. 可以用大寫和小寫字母來表示量的符號。

例：用 m 表示質量，用 v 表示速度，用 V 表示電勢差，用 F 表示力。

3. 用粗黑體斜字表示矢量，如有混淆，可在符號上加箭頭。

例：用 $\mathbf{F}$ (或 $\vec{F}$) 表示力，用 $\mathbf{v}$ (或 $\vec{v}$) 表示速度，
用 $\mathbf{a}$ (或 $\vec{a}$) 表示加速度。

4. 物理量的符號包含量的數值和單位。

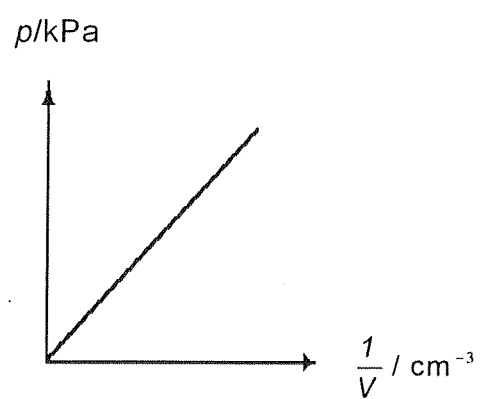
例： $m=5\text{ kg}$, $F=10\text{ N}$, $V=7\text{ V}$

5. 圖表所標繪的數據為不帶單位的純數，所以在圖表中的軸可標為 ' R/Ω '、' V/cm^3 '、' p/kPa ' 等。斜線是用來表示量與單位的比，其比值實際為一個純數。例如： $p=3\text{ kPa}$ ，則 p/kPa 為一個純數 3。

此方法亦適用於表列數據，表中單位不必重複。例如，探討在定溫下空氣壓強和體積的關係時，數據可表列如下：

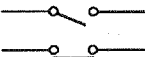
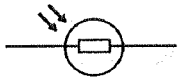
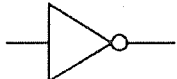
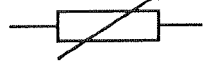
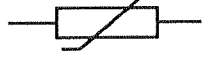
空氣壓強 p/kPa	空氣體積 V/cm^3	體積的倒數 $\frac{1}{V}/\text{cm}^{-3}$

以 p 和 $\frac{1}{V}$ 作圖



4. 附錄三 常用電路符號

物理學廣泛採用圖表符號，尤其在電流和電子學方面。以下列出在學校課業中常用的電路符號以作參考。

	不相連的接線		變壓器
	接線的接頭		安培計
	開關		伏特計
	繼電器線圈		檢流計
	繼電器接點		揚聲器
	電池		蜂鳴器
	電池組		電動機
	接地		二極管
	保險絲		光敏電阻
	燈泡		發光二極管
	定值電阻器		「非」門
	分壓器		「或」門
	變阻器		「或非」門
	熱敏電阻		「與」門
	交流電源		「與非」門