Chapter 1 *Measurement*

失之毫釐，差以千里！差以毫釐，謬以千里！

04. (**a**) Using the conversion factors 1 inch = 2.54 cm exactly and 6 picas = 1 inch, we obtain

$$0.80\text{ cm} = (0.80\text{ cm})(1\text{ inch}/2.54\text{ cm}) \times(6\text{ picas}/1\text{ inch}) \approx 1.9\text{ picas}.$$

(**b**) With 12 points = 1 pica, we have

$$0.80\text{ cm} = (0.80\text{ cm})(1\text{ inch}/2.54\text{ cm}) \times(6\text{ picas}/1\text{ inch})(12\text{ points}/1\text{pica}) = 23\text{ points}.$$

05. Various geometric formulas are given in Appendix E. (**a**) Substituting

$$R = (6.37\times10^6\text{ m})(10^{-3}\text{ km/m}) = 6.37\times10^3\text{ km}$$

into *circumference* $= 2\pi R$, we obtain 4.00×10^4 km. (**b**) The surface area of Earth is

$$A = 4\pi R^2 = 4\pi(6.37\times10^3\text{ km})^2 = 5.10\times10^8\text{ km}^2.$$

(**c**) The volume of Earth is

$$V = (4/3)\pi R^3 = (4/3)\pi(6.37\times10^3\text{ km})^3 = 1.08\times10^{12}\text{ km}^3.$$

07. The volume of ice is given by the product of the semicircular surface area and the thickness. The are of the semicircle is $A = \pi r^2/2$, where r is the radius. Therefore, the volume is

$$V = (\tfrac{1}{2})\pi r^2 z,$$

where z is the ice thickness. Since there are 10^3 m in 1 km and 10^2 cm in 1 m, we have $r = (2000\text{ km})(10^3\text{ m}/1\text{ km})(10^2\text{ cm}/1\text{ m}) = 2000\times10^5$ cm. In these units, the thickness becomes $z = 3000$ m $= (3000\text{ m})(10^2\text{ cm}/1\text{ m}) = 3000\times10^2$ cm, which yields,

$$V = (\tfrac{1}{2})\pi(2000\times10^5\text{ cm})^2(3000\times10^2\text{ cm}) = 1.9\times10^{22}\text{ cm}^3.$$

18. The last day of the 20 centuries is longer than the first day by

$$(20\text{ century})(0.001\text{ s/century}) = 0.02\text{ s}.$$

The average day during the 20 centuries is (0+0.02)/2 = 0.01 (s) longer than the first day. Since the increase occurs uniformly, the cumulative effect T is

T = (average increase in length a day)(number of days)
= (0.01 s/day)(365.25 day/y)(2000 y) = 7305 s

or roughly two hours.

21. If M_E is the mass of Earth, m is the average mass of an atom in Earth, and N is the number of atoms, then $M_E = Nm$ or $N = M_E/m$. We convert mass m to kilograms using Appendix D (1 u = 1.661×10^{-27} kg). Thus,

$$N = M_E/m = 5.98\times10^{24}\text{ kg}/[(40\text{ u})(1.661\times10^{-27}\text{ kg/u})] = 9.0\times10^{49}.$$

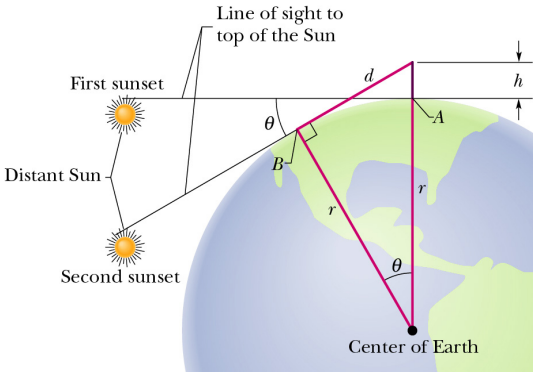
36. When the Sun first disappears while lying down, your line of sight to the top of the Sun is tangent to the Earth's surface at point A shown in the figure. As you stand, elevating your eyes by a height h, the line of sight to the Sun is tangent to the Earth's surface at point B. Let d be the distance from point B to your eyes. From Pythagorean theorem, we have

$$d^2 + r^2 = (r+h)^2 = r^2 + 2rh + h^2,$$

or $d^2 = 2rh + h^2$ where r is the radius of the Earth. Since $r \gg h$, the second term can be dropped, leading to $d^2 \approx 2rh$. Now the angle between the two radii to the two tangent points A and B is θ, which is also the angle through which the Sun moves about Earth during the time interval $t = 11.1$ s. The value of θ can be obtained by using $\theta/360° = t/24\text{ h}$. This yields

$$\theta = \frac{(360°)(11.1\text{ s})}{(24\text{ h})(60\text{ min/h})(60\text{ s/min})} = 0.04625°.$$

Using $d = r\tan\theta$, we have $d^2 = r^2\tan^2\theta = 2rh$, or $r = 2h/\tan^2\theta$. Using the above value for θ and $h = 1.7$ m, we have $r = 5.2\times10^6$ m.



40. (**a**) In atomic mass units, the mass of one molecule is 16+1+1 = 18 (u). Using Eq. 1–9, we find

$$18\text{ u} = (18\text{ u})(1.661\times10^{-27}\text{ kg}/1\text{ u}) = 3.0\times10^{-26}\text{ kg}.$$

(**b**) We divide the total mass by the mass of each molecule and obtain the (approximate) number of water molecules:

$$N \approx (1.4\times10^{21})/(3.0\times10^{-26}) \approx 5\times10^{46}.$$

47. We convert meters to astronomical units, and seconds to minutes, using 1000 m = 1 km, 1 AU = 1.50×10^8 km, and 60 s = 1 min . Thus,

3.0×10^8 m/s becomes $(3.0\times10^8\text{ m})/(1\text{ s})$
$= (2\text{ AU}/100)/(1\text{ min}/60) = 0.12$ AU/min.

(如發現錯誤煩請告知 jyang@mail.ntou.edu.tw, Thanks.)
Updated 951001

SI 7 個基本量及因次

因次 dimension	長度 length	質量 mass	時間 time	溫度 temperature	電流 current	輝(光)度 luminous intensity	物質量 quantity
單位 unit	m meter	kg kilogram	s second	K Kelvin	A Ampere	cd candela 坎德拉*	mol mole

*部譯名稱為新燭光; (小)時 h, 分 min; 奈米 nanometer (nm); 基本量(單位) → 導出量(單位);

第 1 章 量測

時間：銫(Cs)133 原子發出某特定波長的光振動 9,192,631,770 次所需的時間為 **1 秒**(s)。

長度：光於真空中在 299,792,458 分之 1 秒內行進的距離為 **1 公尺**(m)。1 nm (奈米) = 10^{-9} m; 若物體某一維度小於 100 nm 稱為**奈米材料**(cf. 人頭髮厚度/直徑約 100 μm)。

質量：高度及直徑皆為 3.9 公分之鉑銥合金圓柱體的質量為 **1 公斤**(kg)。第二質量標準以碳 12 原子的質量作為 12 原子質量單位(u), 即

$$1\ u = 1.6605402 \times 10^{-27}\ kg.$$

Universal Time (UTC),世界標準時; Universal Time Coordinated (UTC),協調世界標準時

krypton-86,氪(Kr)86; cesium-133,銫(Cs)133

platinum,鉑; iridium銥; carbon-12,碳(C)12

prefix,字首; conversion factor,轉換因子

Krakatoa,克雷克吐爾島(印尼爪哇和蘇門答臘之間一火山小島); Sevres,塞弗爾(巴黎西南郊)

stratosphere,同溫層, 平流層; methane,甲烷,沼氣

mesosphere,中間層,中氣層;

rice paddies,稻田; landfills,垃圾掩埋;

livestock,家畜; flatulence,胃腸氣脹

W1.國家時間與頻率標準實驗室

http://www.stdtime.gov.tw/chinese/home.htm

W2.科學發展月刊

http://nr.stic.gov.tw/ejournal/nscm/nscm.htm

J1.“**自然科學之母—物理科學**”，唐富欽，科學發展 366 期(92 年 6 月) 5。

J2. “**公尺滄桑史—度量衡今昔之一**”，葉李華，科學發展 350 期 (91 年 2 月) 81。

J3.“**一公尺有多長**”, 盧聖華, 科學發展 389 期 (94 年 05 月) 74。

J4.“**經緯度的故事**”，蔡雅芝，科學發展 392 期 (94 年 8 月)，68-77 頁。

J5.“**現代社會的韻律與時間**”，郭文華，科學發展 378 期 (93 年 06 月) 81。

J6.“**遲到不遲到？時刻的文化感知**”，郭文華，科學發展 381 期 (93 年 09 月) 79。

J7.“**問，時間為何物？**”(專輯), 科學人 No.9 (2002 年 11 月號)。

J8.“**奈米科技與生活**”，陳貴賢，科學發展 398 期 (95 年 02 月) 46; <要了解無限前景的奈米科技，也要避免被廣告噱頭所誤導。>

J9.有關 “Smoot” (problem 1-8), 見科學人 No.22 (2003 年 12 月號) 103。

•備忘錄