

題解中心
三角法辭典

薛德烟 吳敬耀 編譯

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上海科學技術出版社出版
(上海瑞金二路450號)

新華書店上海發行所發行 江西印刷公司印刷
开本787×1092 1/32 印張29.125 插頁4 字數830,000
(原新亞科技版共印33,500冊 1935年第1版)
1959年10月新1版 1981年4月第8次印刷
印數：16,501—151,500
統一書號：17119·11 定價：4.00元

限國內發行

内 容 提 要

本書為“數學辭典”的第四冊，內容分平面三角法解法之部，球面三角法解法之部，名詞之部，三角法小史等四門，載有題解 3,354 題，插圖 460 個，卷首附有三角公式集，三首法諸表，卷末附有英漢名詞對照表，全書約計 830 千字，附列題解分類索引，記述簡明，易于查引。

本書出版于 1985 年，內容不尽正確，但為了目前各方面有需要，仍以旧版重印，供各地中、小學教師作備課時的參考。

I. 三角法公式集 平面

測 角 法

◎度與法度之比較.

$$D = G - G/10, \quad G = D + D/9.$$

◎分與法分之關係. $27\mu = 50m.$

◎秒與法秒之關係. $81\sigma = 250s.$

◎度與弧度之比較. $180^\circ = \pi x.$

◎法度與弧度之比較. $200^y = \pi y.$

三 角 函 數 之 定 義

$$\textcircled{1} \sin A = \frac{\text{垂線}}{\text{斜邊}}$$

$$\textcircled{2} \cosec A = \frac{\text{斜邊}}{\text{垂線}}$$

$$\textcircled{3} \cos A = \frac{\text{底邊}}{\text{斜邊}}$$

$$\textcircled{4} \sec A = \frac{\text{斜邊}}{\text{底邊}}$$

$$\textcircled{5} \tan A = \frac{\text{垂線}}{\text{底邊}}$$

$$\textcircled{6} \cot A = \frac{\text{底邊}}{\text{垂線}}$$

$$\textcircled{7} \vers A = 1 - \cos A. \quad \textcircled{8} \covers A = 1 - \sin A.$$

三 角 函 數 之 基 本 關 係

$$\textcircled{1} \sin A \times \cosec A = 1. \quad \textcircled{2} \sin^2 A + \cos^2 A = 1.$$

$$\textcircled{3} \cos A \times \sec A = 1. \quad \textcircled{4} \sec^2 A = 1 + \tan^2 A.$$

$$\textcircled{5} \tan A \times \cot A = 1. \quad \textcircled{6} \cosec^2 A = 1 + \cot^2 A.$$

$$\textcircled{7} \tan A = \frac{\sin A}{\cos A}. \quad \textcircled{8} \cot A = \frac{\cos A}{\sin A}.$$

$$\textcircled{9} \sin A < \tan A < \sec A.$$

$$\textcircled{10} \cos A < \cot A < \cosec A.$$

餘 角 之 三 角 函 數

$$\textcircled{1} \sin(90^\circ - A) = \cos A.$$

$$\textcircled{2} \cos(90^\circ - A) = \sin A.$$

$$\textcircled{3} \tan(90^\circ - A) = \cot A.$$

註意 cosec A, sec A, cot A 分別為 sin A, cos A, tan A 之逆數,故從略.

補 角 之 三 角 函 數

$$\textcircled{1} \sin(180^\circ - A) = \sin A.$$

$$\textcircled{2} \cos(180^\circ - A) = -\cos A.$$

$$\textcircled{3} \tan(180^\circ - A) = -\tan A.$$

負 角 之 三 角 函 數

$$\textcircled{1} \sin(-A) = -\sin A.$$

$$\textcircled{2} \cos(-A) = \cos A.$$

$$\textcircled{3} \tan(-A) = -\tan A.$$

$90^\circ + A$ 之 三 角 函 數

$$\textcircled{1} \sin(90^\circ + A) = \cos A.$$

$$\textcircled{2} \cos(90^\circ + A) = -\sin A.$$

$$\textcircled{3} \tan(90^\circ + A) = -\cot A.$$

(1)

$180^\circ + A$ 之三角函數

$$\textcircled{c} \sin(180^\circ + A) = -\sin A.$$

$$\textcircled{c} \cos(180^\circ + A) = -\cos A.$$

$$\textcircled{c} \tan(180^\circ + A) = \tan A.$$

 $270^\circ - A$ 之三角函數

$$\textcircled{c} \sin(270^\circ - A) = -\cos A.$$

$$\textcircled{c} \cos(270^\circ - A) = -\sin A.$$

$$\textcircled{c} \tan(270^\circ - A) = \cot A.$$

 $270^\circ + A$ 之三角函數

$$\textcircled{c} \sin(270^\circ + A) = -\cos A.$$

$$\textcircled{c} \cos(270^\circ + A) = \sin A.$$

$$\textcircled{c} \tan(270^\circ + A) = -\cot A.$$

 $360^\circ - A$ 之三角函數

$$\textcircled{c} \sin(360^\circ - A) = -\sin A.$$

$$\textcircled{c} \cos(360^\circ - A) = \cos A.$$

$$\textcircled{c} \tan(360^\circ - A) = -\tan A.$$

二角之三角函數

$$\textcircled{c} \sin(A+B) = \sin A \cos B + \cos A \sin B.$$

$$\textcircled{c} \sin(A-B) = \sin A \cos B - \cos A \sin B.$$

$$\textcircled{c} \cos(A+B) = \cos A \cos B - \sin A \sin B.$$

$$\textcircled{c} \cos(A-B) = \cos A \cos B + \sin A \sin B.$$

$$\textcircled{c} \tan(A+B) = \frac{\tan A + \tan B}{1 - \tan A \tan B}.$$

$$\textcircled{c} \tan(A-B) = \frac{\tan A - \tan B}{1 + \tan A \tan B}.$$

$$\textcircled{c} \cot(A+B) = \frac{\cot A \cot B - 1}{\cot A + \cot B}.$$

$$\textcircled{c} \cot(A-B) = \frac{\cot A \cot B + 1}{\cot A - \cot B}.$$

$$\textcircled{c} \sin(A+B) + \sin(A-B) = 2 \sin A \cos B.$$

$$\textcircled{c} \sin(A+B) - \sin(A-B) = 2 \cos A \sin B.$$

$$\textcircled{c} \cos(A+B) + \cos(A-B) = 2 \cos A \cos B.$$

$$\textcircled{c} \cos(A+B) - \cos(A-B) = -2 \sin A \sin B.$$

$$\textcircled{c} \sin C + \sin D = 2 \sin \frac{C+D}{2} \cos \frac{C-D}{2}.$$

$$\textcircled{c} \sin C - \sin D = 2 \cos \frac{C+D}{2} \sin \frac{C-D}{2}.$$

$$\textcircled{c} \cos C + \cos D = 2 \cos \frac{C+D}{2} \cos \frac{C-D}{2}.$$

$$\textcircled{c} \cos C - \cos D = -2 \sin \frac{C+D}{2} \sin \frac{C-D}{2}.$$

三 角 之 三 角 函 数

$$\textcircled{c} \sin(A+B+C)$$

$$= \sin A \cos B \cos C + \cos A \sin B \cos C \\ + \cos A \cos B \sin C - \sin A \sin B \sin C.$$

$$\textcircled{c} \cos(A+B+C)$$

$$= \cos A \cos B \cos C - \cos A \sin B \sin C \\ - \sin A \cos B \sin C - \sin A \sin B \cos C.$$

$$\textcircled{c} \tan(A+B+C) = (\tan A + \tan B + \tan C$$

$$- \tan A \tan B \tan C) / (1 - \tan A \tan B \\ - \tan B \tan C - \tan C \tan A).$$

$$\textcircled{c} \cot(A+B+C) = (\cot A \times \cot B \times \cot C$$

$$- \cot A - \cot B - \cot C) / (\cot B \cot C \\ + \cot C \cot A - \cot A \cot B - 1).$$

若 $A+B+C=90^\circ$, 則

$$1 = \tan A \tan B + \tan B \tan C + \tan C \tan A.$$

$$\cot A \cot B \cot C = \cot A + \cot B + \cot C.$$

◎若 $A + B + C = 180^\circ$, 則

$$\tan A + \tan B + \tan C = \tan A \tan B \tan C.$$

$$\cot B \cot C + \cot C \cot A + \cot A \cot B = 1.$$

倍角之三角函数

$$\textcircled{c} \sin 2A = 2 \sin A \cos A.$$

$$\textcircled{c} \cos 2A = \cos^2 A - \sin^2 A$$

$$= 2 \cos^2 A - 1 = 1 - 2 \sin^2 A.$$

$$\textcircled{c} \tan 2A = \frac{2 \tan A}{1 - \tan^2 A}.$$

$$\textcircled{c} \cot 2A = \frac{\cot^2 A - 1}{2 \cot A}.$$

$$\textcircled{c} \sin 3A = 3 \sin A - 4 \sin^3 A.$$

$$\textcircled{c} \cos 3A = 4 \cos^3 A - 3 \cos A.$$

$$\textcircled{c} \tan 3A = \frac{3 \tan A - \tan^3 A}{1 - 3 \tan^2 A}.$$

$$\textcircled{c} \cot 3A = \frac{\cot^3 A - 3 \cot A}{3 \cot^2 A - 1}.$$

分角之三角函数

$$\textcircled{c} \cos \frac{A}{2} = \pm \sqrt{\frac{1 + \cos A}{2}}.$$

$$\textcircled{c} \sin \frac{A}{2} = \pm \sqrt{\frac{1 - \cos A}{2}}.$$

$$\textcircled{c} 2 \cos \frac{A}{2} = \pm \sqrt{1 + \sin A} \pm \sqrt{1 - \sin A}.$$

$$\textcircled{c} 2 \sin \frac{A}{2} = \pm \sqrt{1 + \sin A} \mp \sqrt{1 - \sin A}.$$

$$\textcircled{c} \sqrt{2} \sin\left(\frac{A}{2} + 45^\circ\right) = \pm \sqrt{1 + \sin A}.$$

$$\textcircled{c} \sqrt{2} \cos\left(\frac{A}{2} + 45^\circ\right) = \pm \sqrt{1 - \sin A}.$$

$$\textcircled{c} \tan \frac{A}{2} = \frac{(-1 \pm \sqrt{1 + \tan^2 A})}{\tan A}$$

$$= (-1 \pm \sec A) \cot A.$$

普偏角之三角函数

$$\textcircled{c} \cos(n \cdot 360^\circ \pm A) = \cos A.$$

$$\textcircled{c} \sin\{n \cdot 180^\circ + (-1)^n A\} = \sin A.$$

$$\textcircled{c} \tan(n \cdot 180^\circ + A) = \tan A.$$

三角形四邊形等

$$\textcircled{c} \frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}.$$

$$\textcircled{c} a = b \cos C + c \cos B \quad \left. \begin{array}{l} \\ \end{array} \right\}$$

$$\textcircled{c} b = c \cos A + a \cos C \quad \left. \begin{array}{l} \\ \end{array} \right\}$$

$$\textcircled{c} c = a \cos B + b \cos A$$

$$\textcircled{c} a^2 = b^2 + c^2 - 2bc \cos A \quad \left. \begin{array}{l} \\ \end{array} \right\}$$

$$\textcircled{c} b^2 = c^2 + a^2 - 2ca \cos B \quad \left. \begin{array}{l} \\ \end{array} \right\}$$

$$\textcircled{c} c^2 = a^2 + b^2 - 2ab \cos C \quad \left. \begin{array}{l} \\ \end{array} \right\}$$

$$\textcircled{c} \cos A = (b^2 + c^2 - a^2) / 2bc$$

$$\textcircled{c} \cos B = (c^2 + a^2 - b^2) / 2ca \quad \left. \begin{array}{l} \\ \end{array} \right\}$$

$$\textcircled{c} \cos C = (a^2 + b^2 - c^2) / 2ab \quad \left. \begin{array}{l} \\ \end{array} \right\}$$

式中假定 $s = \frac{1}{2}(a+b+c)$.

$$\textcircled{c} \sin \frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}} \quad \left. \begin{array}{l} \\ \end{array} \right\}$$

$$\textcircled{c} \sin \frac{B}{2} = \sqrt{\frac{(s-c)(s-a)}{ca}} \quad \left. \begin{array}{l} \\ \end{array} \right\}$$

$$\textcircled{c} \sin \frac{C}{2} = \sqrt{\frac{(s-a)(s-b)}{ab}} \quad \left. \begin{array}{l} \\ \end{array} \right\}$$

$$\textcircled{c} \cos \frac{A}{2} = \sqrt{\frac{s(s-a)}{bc}} \quad \left. \begin{array}{l} \\ \end{array} \right\}$$

$$\textcircled{c} \cos \frac{B}{2} = \sqrt{\frac{s(s-b)}{ca}} \quad \left. \begin{array}{l} \\ \end{array} \right\}$$

$$\textcircled{c} \cos \frac{C}{2} = \sqrt{\frac{s(s-c)}{ab}} \quad \left. \begin{array}{l} \\ \end{array} \right\}$$

$$\textcircled{①} \tan \frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}}$$

$$\textcircled{②} \tan \frac{B}{2} = \sqrt{\frac{(s-c)(s-a)}{s(s-b)}}$$

$$\textcircled{③} \tan \frac{C}{2} = \sqrt{\frac{(s-a)(s-b)}{s(s-c)}}$$

$$\textcircled{④} (b+c) \sin \frac{1}{2} A = a \cos \frac{1}{2} (B-C)$$

$$\textcircled{⑤} (c+a) \sin \frac{1}{2} B = b \cos \frac{1}{2} (C-A)$$

$$\textcircled{⑥} (a+b) \sin \frac{1}{2} C = c \cos \frac{1}{2} (A-B)$$

$$\textcircled{⑦} \frac{b-c}{b+c} \cot \frac{A}{2} = \tan \frac{B-C}{2}$$

$$\textcircled{⑧} \frac{c-a}{c+a} \cot \frac{B}{2} = \tan \frac{C-A}{2}$$

$$\textcircled{⑨} \frac{a-b}{a+b} \cot \frac{C}{2} = \tan \frac{A-B}{2}$$

$$\textcircled{⑩} \sin A = \frac{2\Delta}{bc}, \quad \sin B = \frac{2\Delta}{ca}, \quad \sin C = \frac{2\Delta}{ab}$$

但 $\Delta = \sqrt{s(s-a)(s-b)(s-c)}$

$$\textcircled{⑪} r = (s-a) \tan \frac{A}{2}, \quad r_1 = s \tan \frac{A}{2}$$

$$\textcircled{⑫} r_2 = s \tan \frac{B}{2}, \quad r_3 = s \tan \frac{C}{2}$$

$$\textcircled{⑬} \text{至 } a \text{ 之中線} = \frac{1}{2} \sqrt{(b^2 + c^2 + 2bc \cos A)}$$

$$\textcircled{⑭} \text{角 } A \text{ 之內二等分線} = \frac{2bc \cos \frac{A}{2}}{b+c}$$

$$\textcircled{⑮} \text{角 } A \text{ 之外二等分線} = \frac{2bc \cos \frac{A}{2}}{b-c}$$

$$\textcircled{⑯} \Delta = \frac{1}{2} ab \sin C = \frac{b^2 \sin A \sin C}{2 \sin B}$$

$$= \sqrt{s(s-a)(s-b)(s-c)} = rs$$

$$= r_1(s-a) = r_2(s-b) = r_3(s-c)$$

$$= \frac{1}{2} h_a a = \frac{abc}{4R}$$

$$\textcircled{⑰} \text{圓之內接四邊形之面積}$$

$$= \sqrt{(s-a)(s-b)(s-c)(s-d)}.$$

◎任意四邊形之面積

$$= \sqrt{\{(s-a)(s-b)(s-c)(s-d)\} - abcd \times \cos^2 \frac{A+C}{2}}.$$

◎外切四邊形之面積 = $\sqrt{abcd} \cdot \sin \frac{A+C}{2}$.

◎內接且外切四邊形之面積 = \sqrt{abcd} .

◎正多角形之邊心距 $r = a/2 \tan \frac{\pi}{n}$.

◎正多角形之半徑 $R = a/2 \sin \frac{\pi}{n}$.

◎同面積 = $\frac{n}{2} R^2 \sin \frac{2\pi}{n} = nr^2 \tan \frac{\pi}{n}$.

De Moivre 氏 定 理

$$\textcircled{⑰} (\cos \theta + i \sin \theta)^n = \cos n\theta + i \sin n\theta.$$

$$\textcircled{⑱} \cos \alpha = 1 - \frac{\alpha^2}{2!} + \frac{\alpha^4}{4!} - \frac{\alpha^6}{6!} + \dots$$

$$\textcircled{⑲} \sin \alpha = \alpha - \frac{\alpha^3}{3!} + \frac{\alpha^5}{5!} - \frac{\alpha^7}{7!} + \dots$$

三 角 函 數 之 展 開

$$\textcircled{⑳} \sin n\theta = n \sin \theta - \frac{n(n^2-1)}{3!} \sin^3 \theta \\ + \frac{n(n^2-1)(n^2-3^2)}{5!} \sin^5 \theta \dots$$

$$\textcircled{㉑} \cos n\theta = \cos \theta \left\{ 1 - \frac{n^2-1}{2!} \sin^2 \theta \right. \\ \left. + \frac{(n^2-1)(n^2-3^2)}{4!} \sin^4 \theta \dots \right\}$$

三 角 函 數 之 指 數 值

$$\textcircled{㉒} \cos \theta = \frac{1}{2} (e^{i\theta} + e^{-i\theta})$$

$$\textcircled{㉓} \sin \theta = \frac{1}{2i} (e^{i\theta} - e^{-i\theta})$$

$$\textcircled{㉔} i \tan \theta = \frac{e^{i\theta} - e^{-i\theta}}{e^{i\theta} + e^{-i\theta}}$$

級 數 之 和

$$\begin{aligned} \cos \alpha + \cos(\alpha + 2\beta) + \cos(\alpha + 4\beta) + \dots + \cos\{\alpha \\ + 2(n-1)\beta\} &= \frac{\cos\{\alpha + (n-1)\beta\} \sin n\beta}{\sin \beta}, \\ \sin \alpha + \sin(\alpha + 2\beta) + \sin(\alpha + 4\beta) + \dots + \sin\{\alpha \\ + 2(n-1)\beta\} &= \frac{\sin\{\alpha + (n-1)\beta\} \sin n\beta}{\sin \beta}. \end{aligned}$$

$$\begin{aligned} \cos \alpha + \cos\left(\alpha + \frac{2\pi}{n}\right) + \cos\left(\alpha + \frac{4\pi}{n}\right) + \dots \\ + \cos\left\{\alpha + \frac{2(n-1)\pi}{n}\right\} &= 0, \\ \sin \alpha + \sin\left(\alpha + \frac{2\pi}{n}\right) + \sin\left(\alpha + \frac{4\pi}{n}\right) + \dots \\ + \sin\left\{\alpha + \frac{2(n-1)\pi}{n}\right\} &= 0. \end{aligned}$$

三 角 函 數 式 之 因 數 分 解

◎ n 為偶數時, $x^n - 1 = (x-1)(x+1)\left(x^2 - 2x \cos \frac{2\pi}{n} + 1\right)\left(x^2 - 2x \cos \frac{4\pi}{n} + 1\right) \times \dots$
 $\dots \left\{x^2 - 2x \cos \frac{n-4}{n}\pi + 1\right\} \left\{x^2 - 2x \cos \frac{n-2}{n}\pi + 1\right\}.$

◎ n 為奇數時, $x^n - 1 = (x-1)\left(x^2 - 2x \cos \frac{2\pi}{n} + 1\right)\left(x^2 - 2x \cos \frac{4\pi}{n} + 1\right) \times \dots$
 $\dots \left\{x^2 - 2x \cos \frac{n-3}{n}\pi + 1\right\} \left\{x^2 - 2x \cos \frac{n-1}{n}\pi + 1\right\}.$

◎ n 為偶數時, $x^n + 1 = \left(x^2 - 2x \cos \frac{\pi}{n} + 1\right)\left(x^2 - 2x \cos \frac{3\pi}{n} + 1\right)\left(x^2 - 2x \cos \frac{5\pi}{n} + 1\right) \times \dots$
 $\dots \left\{x^2 - 2x \cos \frac{n-3}{n}\pi + 1\right\} \left\{x^2 - 2x \cos \frac{n-1}{n}\pi + 1\right\}.$

◎ n 為奇數時, $x^n + 1 = (x+1)\left(x^2 - 2x \cos \frac{\pi}{n} + 1\right)\left(x^2 - 2x \cos \frac{3\pi}{n} + 1\right) \times \dots$
 $\dots \left\{x^2 - 2x \cos \frac{n-4}{n}\pi + 1\right\} \left\{x^2 - 2x \cos \frac{n-2}{n}\pi + 1\right\}.$

◎ $x^n - x^{-n} = (x - x^{-n})(x + x^{-1} - 2 \cos \frac{\pi}{n})(x + x^{-1} - 2 \cos \frac{2\pi}{n}) \times \dots$
 $\dots (x + x^{-1} - 2 \cos \frac{n-1}{n}\pi).$

◎ $x^n + x^{-n} = (x + x^{-1} - 2 \cos \frac{\pi}{2n})(x + x^{-1} - 2 \cos \frac{3\pi}{2n}) \dots (x + x^{-1} - 2 \cos \frac{2n-1}{2n}\pi).$

◎ $x^{2n} - 2x^n \cos \theta + 1 = \left(x^2 - 2x \cos \frac{\theta}{n} + 1\right)\left(x^2 - 2x \cos \frac{2\pi+\theta}{n} + 1\right)\left(x^2 - 2x \cos \frac{4\pi+\theta}{n} + 1\right) \times \dots$
 $\dots \left\{x^2 - 2x \cos \frac{(2n-4)\pi+\theta}{n} + 1\right\} \left\{x^2 - 2x \cos \frac{(2n-2)\pi+\theta}{n} + 1\right\}.$

◎ $x^n + x^{-n} - 2 \cos n\theta = (x + x^{-1} - 2 \cos \theta)\left\{x + x^{-1} - 2 \cos\left(\theta + \frac{2\pi}{n}\right)\right\} \times \dots$
 $\dots \left\{x + x^{-1} - 2 \cos\left(\theta + \frac{2n-2}{n}\right)\right\}.$

II. 三角法公式集 球面

基 本 公 式

$$\textcircled{1} \cos a = \cos b \cos c + \sin b \sin c \cos A.$$

$$\textcircled{2} \cos b = \cos c \cos a + \sin c \sin a \cos B.$$

$$\textcircled{3} \cos c = \cos a \cos b + \sin a \sin b \cos C.$$

sin A 之 公 式

$$\textcircled{1} \sin A = \sqrt{(1 - \cos^2 a - \cos^2 b - \cos^2 c + 2 \cos a \times \cos b \cos c) / (\sin b \sin c)}$$

$$= 2n / (\sin b \sin c).$$

$$\text{但 } (\sin s \sin(s-a) \sin(s-b) \sin(s-c))^{\frac{1}{2}}$$

$$= n \text{ 及 } 2s = a+b+c.$$

餘 切 正 弦 之 公 式

$$\textcircled{1} \cot a \sin b = \cot A \sin C + \cos b \cos C.$$

$$\textcircled{2} \cot b \sin a = \cot B \sin C + \cos a \cos C.$$

$$\textcircled{3} \cot b \sin c = \cot B \sin A + \cos c \cos A.$$

$$\textcircled{4} \cot c \sin b = \cot C \sin A + \cos b \cos A.$$

$$\textcircled{5} \cot c \sin a = \cot C \sin B + \cos a \cos B.$$

$$\textcircled{6} \cot a \sin c = \cot A \sin B + \cos c \cos B.$$

正 弦 比 例

$$\textcircled{1} \sin A / \sin a = \sin B / \sin b = \sin C / \sin c$$

$$= 2n / (\sin a \sin b \sin c).$$

半 角 之 公 式

$$\textcircled{1} \sin \frac{A}{2} = \sqrt{\frac{\sin(s-b)\sin(s-c)}{\sin b \sin c}}.$$

$$\textcircled{2} \cos \frac{A}{2} = \sqrt{\frac{\sin s \sin(s-a)}{\sin b \sin c}}.$$

$$\textcircled{3} \tan \frac{A}{2} = \sqrt{\frac{\sin(s-b)\sin(s-c)}{\sin s \sin(s-a)}}.$$

半 弧 之 公 式

$$\textcircled{1} \sin \frac{a}{2} = \sqrt{-\frac{\cos S \cos(S-A)}{\sin S \sin C}}.$$

$$\textcircled{2} \cos \frac{a}{2} = \sqrt{\frac{\cos(S-B)\cos(S-C)}{\sin S \sin C}}.$$

$$\textcircled{3} \tan \frac{a}{2} = \sqrt{-\frac{\cos S \cos(S-A)}{\cos(S-B)\cos(S-C)}}.$$

$$\text{但 } 2S = A + B + C.$$

Napier 氏 公 式

$$\textcircled{1} \tan \frac{1}{2}(A+B) = \frac{\cos \frac{1}{2}(a-b)}{\cos \frac{1}{2}(a+b)} \cot \frac{C}{2}.$$

$$\textcircled{2} \tan \frac{1}{2}(A-B) = \frac{\sin \frac{1}{2}(a-b)}{\sin \frac{1}{2}(a+b)} \cot \frac{C}{2}.$$

$$\textcircled{3} \tan \frac{1}{2}(a+b) = \frac{\cos \frac{1}{2}(A-B)}{\cos \frac{1}{2}(A+B)} \tan \frac{C}{2}.$$

$$\textcircled{④} \tan \frac{1}{2}(a-b) = \frac{\sin \frac{1}{2}(A-B)}{\sin \frac{1}{2}(A+B)} \tan \frac{c}{2}.$$

Delambre 氏比例式

$$\textcircled{⑤} \sin \frac{1}{2}(A+B) \cos \frac{1}{2}c = \cos \frac{1}{2}(a-b) \cos \frac{1}{2}C.$$

$$\textcircled{⑥} \sin \frac{1}{2}(A-B) \sin \frac{1}{2}c = \sin \frac{1}{2}(a-b) \cos \frac{1}{2}C.$$

$$\textcircled{⑦} \cos \frac{1}{2}(A+B) \cos \frac{1}{2}c = \cos \frac{1}{2}(a+b) \sin \frac{1}{2}C.$$

$$\textcircled{⑧} \cos \frac{1}{2}(A-B) \sin \frac{1}{2}c = \sin \frac{1}{2}(a+b) \sin \frac{1}{2}C.$$

球面直角三角形

[C 為直角]

$$\textcircled{⑨} \sin b = \sin B \sin c \}$$

$$\textcircled{⑩} \sin a = \sin A \sin c \}$$

$$\textcircled{⑪} \tan a = \cos B \tan c \}$$

$$\textcircled{⑫} \tan b = \cos A \tan c \}$$

$$\textcircled{⑬} \tan b = \tan B \sin a \}$$

$$\textcircled{⑭} \tan a = \tan A \sin b \}$$

$$\textcircled{⑮} \tan A \tan B = 1/\cos c \}$$

$$\textcircled{⑯} \cot A \cot B = \cos c \}$$

內切圓傍切圓外接圓

$$\textcircled{⑰} \tan r = \frac{n}{\sin s} = \tan \frac{A}{2} \sin(s-a)$$

$$= \frac{\sin \frac{1}{2}B \sin \frac{1}{2}C}{\cos \frac{1}{2}A} \sin a$$

$$= \frac{N}{2 \cos \frac{1}{2}A \cos \frac{1}{2}B \cos \frac{1}{2}C}.$$

$$\text{但 } N = \{-\cos S \cos(S-A) \cos(S-B)$$

$$\times \cos(S-C)\}^{\frac{1}{2}}.$$

$$\textcircled{⑱} \cot r = \frac{1}{2N} \{ \cos S + \cos(S-A) + \cos(S-B) \\ + \cos(S-C) \}.$$

$$\textcircled{⑲} \tan r_1 = \frac{n}{\sin(s-a)} = \tan \frac{A}{2} \sin s \\ = \frac{\cos \frac{1}{2}B \cos \frac{1}{2}C}{\cos \frac{1}{2}A} \sin a \\ = \frac{N}{2 \cos \frac{1}{2}A \sin \frac{1}{2}B \sin \frac{1}{2}C}.$$

$$\textcircled{⑳} \cot r_1 = \frac{1}{2N} \{ -\cos S - \cos(S-A) \\ - \cos(S-B) + \cos(S-C) \}.$$

$$\textcircled{㉑} \tan R = -\frac{\cos S}{N} = \frac{\sin \frac{1}{2}a}{\sin A \cos \frac{1}{2}b \cos \frac{1}{2}c} \\ = \frac{\tan \frac{1}{2}a}{\cos(S-A)} = \frac{2 \sin \frac{1}{2}a \sin \frac{1}{2}b \sin \frac{1}{2}c}{n} \\ = \frac{1}{2n} \{ \sin(s-a) + \sin(s-b) \\ + \sin(s-c) - \sin s \}.$$

$$\textcircled{㉒} \tan R_1 = \frac{\cos(S-A)}{N} = \frac{\sin \frac{1}{2}a}{\sin A \sin \frac{1}{2}b \sin \frac{1}{2}c} \\ = \frac{\tan \frac{1}{2}a}{-\cos S} = \frac{2 \sin \frac{1}{2}a \cos \frac{1}{2}b \cos \frac{1}{2}c}{n} \\ = \frac{1}{2n} \{ \sin s - \sin(s-a) + \sin(s-b) \\ + \sin(s-c) \}.$$

$$\textcircled{㉓} (\cot r + \tan R)^2$$

$$= \frac{1}{4n^2} (\sin a + \sin b + \sin c)^2 - 1.$$

$$\textcircled{㉔} (\cot r_1 - \tan R)^2$$

$$= \frac{1}{4n^2} (\sin b + \sin c - \sin a)^2 - 1.$$

面 積

$$\textcircled{㉕} \text{球面三角形 ABC} = (A+B+C-\pi)r^2.$$

$$\textcircled{㉖} \text{多角形} = \{\Sigma - (n-2)\pi\}r^2.$$

[但 Σ 為多角形各角之和].

Cagnoli 氏 定 理

$$\textcircled{1} \sin \frac{1}{2}E = \sqrt{\frac{\{\sin s \sin(s-a) \sin(s-b) \sin(s-c)\}}{2 \cos \frac{1}{2}a \cos \frac{1}{2}b \cos \frac{1}{2}c}}. \text{ 但 } E = A + B + C - \pi.$$

Lhuilier 氏 定 理

$$\textcircled{2} \tan \frac{1}{2}E = \sqrt{\{\tan \frac{1}{2}s \tan \frac{1}{2}(s-a) \tan \frac{1}{2}(s-b) \tan \frac{1}{2}(s-c)\}}.$$

III. 三 角 法 諸 表

三 角 函 數 相 互 之 關 係

| | $\sin \theta = x$ | $\cos \theta = x$ | $\tan \theta = x$ | $\cot \theta = x$ | $\sec \theta = x$ | $\operatorname{cosec} \theta = x$ |
|---------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|----------------------------|-----------------------------------|
| $\sin \theta =$ | x | $\sqrt{1-x^2}$ | $\frac{x}{\sqrt{1+x^2}}$ | $\frac{1}{\sqrt{1+x^2}}$ | $\sqrt{(x^2-1)} \over x$ | $\frac{1}{x}$ |
| $\cos \theta =$ | $\sqrt{1-x^2}$ | x | $\frac{1}{\sqrt{1+x^2}}$ | $\frac{x}{\sqrt{1+x^2}}$ | $\frac{1}{x}$ | $\sqrt{(x^2-1)} \over x$ |
| $\tan \theta =$ | $\frac{x}{\sqrt{1-x^2}}$ | $\frac{\sqrt{1-x^2}}{x}$ | x | $\frac{1}{x}$ | $\sqrt{(x^2-1)}$ | $\frac{1}{\sqrt{(x^2-1)}}$ |
| $\cot \theta =$ | $\frac{\sqrt{1-x^2}}{x}$ | $\frac{x}{\sqrt{1-x^2}}$ | $\frac{1}{x}$ | x | $\frac{1}{\sqrt{(x^2-1)}}$ | $\sqrt{(x^2-1)}$ |
| $\sec \theta =$ | $\frac{1}{\sqrt{1-x^2}}$ | $\frac{1}{x}$ | $\sqrt{1+x^2}$ | $\sqrt{1+x^2} \over x$ | x | $\frac{x}{\sqrt{(x^2-1)}}$ |
| $\operatorname{cosec} \theta =$ | $\frac{1}{x}$ | $\frac{1}{\sqrt{1-x^2}}$ | $\sqrt{1+x^2} \over x$ | $\sqrt{1+x^2} \over x$ | $\frac{x}{\sqrt{(x^2-1)}}$ | x |

逆三角函數相互之關係

| | \sin^{-1} | \cos^{-1} | \tan^{-1} | \cot^{-1} | \sec^{-1} | \cosec^{-1} |
|------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| $\sin^{-1}x =$ | x | $\sqrt{1-x^2}$ | $\frac{x}{\sqrt{1-x^2}}$ | $\frac{\sqrt{1-x^2}}{x}$ | $\frac{1}{\sqrt{1-x^2}}$ | $\frac{1}{x}$ |
| $\cos^{-1}x =$ | $\sqrt{1-x^2}$ | x | $\frac{\sqrt{1-x^2}}{x}$ | $\frac{x}{\sqrt{1-x^2}}$ | $\frac{1}{x}$ | $\frac{1}{\sqrt{1-x^2}}$ |
| $\tan^{-1}x =$ | $\frac{x}{\sqrt{1+x^2}}$ | $\frac{1}{\sqrt{1+x^2}}$ | x | $\frac{1}{x}$ | $\sqrt{1+x^2}$ | $\frac{\sqrt{1+x^2}}{x}$ |
| $\cot^{-1}x =$ | $\frac{1}{\sqrt{1+x^2}}$ | $\frac{x}{\sqrt{1+x^2}}$ | $\frac{1}{x}$ | x | $\frac{\sqrt{1+x^2}}{x}$ | $\sqrt{1+x^2}$ |
| $\sec^{-1}x =$ | $\frac{\sqrt{x^2-1}}{x}$ | $\frac{1}{x}$ | $\sqrt{x^2-1}$ | $\frac{1}{\sqrt{x^2-1}}$ | x | $\frac{x}{\sqrt{x^2-1}}$ |
| $\cosec^{-1}x =$ | $\frac{1}{x}$ | $\frac{\sqrt{x^2-1}}{x}$ | $\frac{1}{\sqrt{x^2-1}}$ | $\sqrt{x^2-1}$ | $\frac{x}{\sqrt{x^2-1}}$ | x |

雙曲線函數相互之關係

| $\sin hu = x$ | $\cosh hu = x$ | $\tan hu = x$ | $\cot hu = x$ | $\sec hu = x$ | $\cosech hu = x$ |
|----------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| $\sin hu =$ | x | $\sqrt{x^2-1}$ | $\frac{x}{\sqrt{1-x^2}}$ | $\frac{1}{\sqrt{x^2-1}}$ | $\frac{\sqrt{1-x^2}}{x}$ |
| $\cosh hu =$ | $\sqrt{1+x^2}$ | x | $\frac{1}{\sqrt{1-x^2}}$ | $\frac{x}{\sqrt{x^2-1}}$ | $\frac{1}{x}$ |
| $\tan hu =$ | $\frac{x}{\sqrt{1+x^2}}$ | $\frac{\sqrt{x^2-1}}{x}$ | x | $\frac{1}{x}$ | $\sqrt{1-x^2}$ |
| $\cot hu =$ | $\frac{\sqrt{x^2+1}}{x}$ | $\frac{x}{\sqrt{x^2-1}}$ | $\frac{1}{x}$ | x | $\frac{1}{\sqrt{1-x^2}}$ |
| $\sec hu =$ | $\frac{1}{\sqrt{1+x^2}}$ | $\frac{1}{x}$ | $\sqrt{1-x^2}$ | $\frac{\sqrt{x^2-1}}{x}$ | $\frac{x}{\sqrt{1+x^2}}$ |
| $\cosech hu =$ | $\frac{1}{x}$ | $\frac{1}{\sqrt{x^2-1}}$ | $\frac{\sqrt{1-x^2}}{x}$ | $\sqrt{x^2-1}$ | $\frac{x}{\sqrt{1-x^2}}$ |

三 角 函 數 符 號 及 變 化

| 象限 函數 | 第一 | 第二 | 第三 | 第四 |
|----------|--------------|----------------|----------------|----------------|
| 正弦 | 由 0 至 1 正 | 由 1 至 0 正 | 由 0 至 -1 負 | 由 -1 至 0 負 |
| 餘割 | 由 0 至 1 正 | 由 1 至 ∞ 負 | 由 -∞ 至 -1 負 | 由 -1 至 -∞ 負 |
| 餘弦 | 由 1 至 0 正 | 由 0 至 -1 負 | 由 -1 至 0 負 | 由 0 至 1 正 |
| 正割 | 由 1 至 ∞ 正 | 由 -∞ 至 -1 負 | 由 -1 至 -∞ 負 | 由 ∞ 至 1 正 |
| 正切 | 由 0 至 ∞ 正 | 由 -∞ 至 0 負 | 由 0 至 ∞ 正 | 由 -∞ 至 0 負 |
| 餘切 | 由 ∞ 至 0 正 | 由 0 至 -∞ 負 | 由 ∞ 至 0 正 | 由 0 至 -∞ 負 |

三 角 函 數 大 小

| 度 函數 | 0° | 30° | 45° | 60° | 90° | 120° | 135° | 150° | 180° | 度 函數 |
|---------|----------|----------------------|----------------------|----------------------|----------|-----------------------|-----------------------|-----------------------|----------|---------|
| sin. | 0 | $\frac{1}{2}$ | $\frac{1}{\sqrt{2}}$ | $\frac{\sqrt{3}}{2}$ | 1 | $\frac{\sqrt{3}}{2}$ | $\frac{1}{\sqrt{2}}$ | $\frac{1}{2}$ | 0 | 正弦 |
| cos. | 1 | $\frac{\sqrt{3}}{2}$ | $\frac{1}{\sqrt{2}}$ | $\frac{1}{2}$ | 0 | $-\frac{1}{2}$ | $-\frac{1}{\sqrt{2}}$ | $-\frac{\sqrt{3}}{2}$ | -1 | 餘弦 |
| tan. | 0 | $\frac{1}{\sqrt{3}}$ | 1 | $\sqrt{3}$ | ∞ | $-\sqrt{3}$ | -1 | $-\frac{1}{\sqrt{3}}$ | 0 | 正切 |
| cot. | ∞ | $\sqrt{3}$ | 1 | $\frac{1}{\sqrt{3}}$ | 0 | $-\frac{1}{\sqrt{3}}$ | -1 | $-\sqrt{3}$ | ∞ | 餘切 |
| sec. | 1 | $\frac{2}{\sqrt{3}}$ | $\sqrt{2}$ | 2 | ∞ | -2 | $-\sqrt{2}$ | $-\frac{2}{\sqrt{3}}$ | -1 | 正割 |
| cosec. | ∞ | 2 | $\sqrt{2}$ | $\frac{2}{\sqrt{3}}$ | 1 | $\frac{2}{\sqrt{3}}$ | $\sqrt{2}$ | 2 | ∞ | 餘割 |

特 别 角 之 三 角 函 数

| | sin | cos | tan | cot | |
|------------------------------|-----------------------------------|-----------------------------------|-------------------------------------|-------------------------------------|------------------------------|
| $\frac{1}{12}\pi = 15^\circ$ | $\frac{\sqrt{3} - \sqrt{2}}{4}$ | $\frac{\sqrt{3} + \sqrt{2}}{4}$ | $2 - \sqrt{3}$ | $2 + \sqrt{3}$ | $\frac{5}{12}\pi = 75^\circ$ |
| | cos | sin | cot | tan | |
| $\frac{1}{10}\pi = 18^\circ$ | $\frac{\sqrt{5} - 1}{4}$ | $\frac{\sqrt{10} + 2\sqrt{5}}{4}$ | $\frac{1}{5}\sqrt{25 - 10\sqrt{5}}$ | $\sqrt{5} + 2\sqrt{5}$ | $\frac{2}{5}\pi = 72^\circ$ |
| $\frac{1}{5}\pi = 36^\circ$ | $\frac{\sqrt{10} - 2\sqrt{5}}{4}$ | $\frac{\sqrt{5} + 1}{4}$ | $\sqrt{5} - 2\sqrt{5}$ | $\frac{1}{5}\sqrt{25 + 10\sqrt{5}}$ | $\frac{3}{10}\pi = 54^\circ$ |

特 别 角 之 正 弦

| | |
|-------------------------------------|--|
| $\sin(3^\circ = \frac{1}{60}\pi)$ | $\frac{1}{16}\{(\sqrt{6} + \sqrt{2})(\sqrt{5} - 1) - 2(\sqrt{3} - 1)\sqrt{5} + \sqrt{5}\}$ |
| $\sin(6^\circ = \frac{1}{30}\pi)$ | $\frac{1}{8}(\sqrt{30} - 6\sqrt{5} - \sqrt{5} - 1)$ |
| $\sin(9^\circ = \frac{1}{20}\pi)$ | $\frac{1}{8}(\sqrt{10} + \sqrt{2} - 2\sqrt{5} - \sqrt{5})$ |
| $\sin(12^\circ = \frac{1}{15}\pi)$ | $\frac{1}{8}(\sqrt{10} + 2\sqrt{5} - \sqrt{15} + \sqrt{3})$ |
| $\sin(15^\circ = \frac{1}{12}\pi)$ | $\frac{1}{4}(\sqrt{6} - \sqrt{2})$ |
| $\sin(18^\circ = \frac{1}{10}\pi)$ | $\frac{1}{4}(\sqrt{5} - 1)$ |
| $\sin(21^\circ = \frac{7}{60}\pi)$ | $\frac{1}{16}\{2(\sqrt{3} + 1)\sqrt{5} - \sqrt{5} - (\sqrt{6} - \sqrt{2})(\sqrt{5} + 1)\}$ |
| $\sin(24^\circ = \frac{2}{15}\pi)$ | $\frac{1}{8}(\sqrt{15} + \sqrt{3} - \sqrt{10} - 2\sqrt{5})$ |
| $\sin(27^\circ = \frac{3}{20}\pi)$ | $\frac{1}{8}(2\sqrt{5} + \sqrt{5} - \sqrt{10} + \sqrt{2})$ |
| $\sin(30^\circ = \frac{1}{6}\pi)$ | $\frac{1}{2}$ |
| $\sin(33^\circ = \frac{11}{60}\pi)$ | $\frac{1}{16}\{(\sqrt{6} + \sqrt{2})(\sqrt{5} - 1) + 2(\sqrt{3} - 1)\sqrt{5} + \sqrt{5}\}$ |

| | |
|-------------------------------------|--|
| $\sin(36^\circ = \frac{1}{5}\pi)$ | $\frac{1}{4}\sqrt{10 - 2\sqrt{5}}$ |
| $\sin(39^\circ = \frac{13}{60}\pi)$ | $\frac{1}{16}\{(\sqrt{6} + \sqrt{2})(\sqrt{5} + 1) - 2(\sqrt{3} - 1)\sqrt{5} - \sqrt{5}\}$ |
| $\sin(42^\circ = \frac{7}{30}\pi)$ | $\frac{1}{8}(\sqrt{30} + 6\sqrt{5} - \sqrt{5} + 1)$ |
| $\sin(45^\circ = \frac{1}{4}\pi)$ | $\frac{1}{2}\sqrt{2}$ |
| $\sin(48^\circ = \frac{4}{15}\pi)$ | $\frac{1}{8}(\sqrt{10} + 2\sqrt{5} + \sqrt{15} - \sqrt{3})$ |
| $\sin(51^\circ = \frac{17}{60}\pi)$ | $\frac{1}{16}\{2(\sqrt{3} + 1)\sqrt{5} - \sqrt{5} + (\sqrt{6} - \sqrt{2})(\sqrt{5} + 1)\}$ |
| $\sin(54^\circ = \frac{3}{10}\pi)$ | $\frac{1}{4}(\sqrt{5} + 1)$ |
| $\sin(57^\circ = \frac{19}{60}\pi)$ | $\frac{1}{16}\{2(\sqrt{3} + 1)\sqrt{5} + \sqrt{5} - (\sqrt{6} - \sqrt{2})(\sqrt{5} - 1)\}$ |
| $\sin(60^\circ = \frac{1}{3}\pi)$ | $\frac{1}{2}\sqrt{3}$ |
| $\sin(63^\circ = \frac{7}{20}\pi)$ | $\frac{1}{8}(2\sqrt{5} + \sqrt{5} + \sqrt{10} - \sqrt{2})$ |
| $\sin(66^\circ = \frac{11}{30}\pi)$ | $\frac{1}{8}(\sqrt{30} - 6\sqrt{5} + \sqrt{5} + 1)$ |
| $\sin(69^\circ = \frac{23}{60}\pi)$ | $\frac{1}{16}\{(\sqrt{6} + \sqrt{2})(\sqrt{5} + 1) + 2(\sqrt{3} - 1)\sqrt{5} - \sqrt{5}\}$ |
| $\sin(72^\circ = \frac{2}{5}\pi)$ | $\frac{1}{4}\sqrt{10 + 2\sqrt{5}}$ |
| $\sin(75^\circ = \frac{5}{12}\pi)$ | $\frac{1}{4}(\sqrt{6} + \sqrt{2})$ |
| $\sin(78^\circ = \frac{13}{30}\pi)$ | $\frac{1}{8}(\sqrt{30} + 6\sqrt{5} + \sqrt{5} - 1)$ |
| $\sin(81^\circ = \frac{9}{20}\pi)$ | $\frac{1}{8}(\sqrt{10} + \sqrt{2} + 2\sqrt{5} - \sqrt{5})$ |
| $\sin(84^\circ = \frac{14}{30}\pi)$ | $\frac{1}{8}(\sqrt{15} + \sqrt{3} + \sqrt{10} - 2\sqrt{5})$ |
| $\sin(87^\circ = \frac{29}{60}\pi)$ | $\frac{1}{16}\{2(\sqrt{3} + 1)\sqrt{5} + \sqrt{5} + (\sqrt{6} - \sqrt{2})(\sqrt{5} - 1)\}$ |

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