

Учебен център "СОЛЕМА"

обучение по математика, физика, български и английски език, компютър

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Тригонометрични формули

(навсякъде във формулите "+" или "-" пред корена имаме в зависимост на това в кой квадрант се намира второто рамо на ъгъла)

1. Основни тригонометрични равенства:

1.1: $\sin^2 \alpha + \cos^2 \alpha = 1$

1.2: $\operatorname{tg} \alpha \operatorname{cotg} \alpha = 1$

1.3: $\operatorname{tg} \alpha = \frac{\sin \alpha}{\cos \alpha}; \quad \operatorname{cotg} \alpha = \frac{\cos \alpha}{\sin \alpha}$

2. Връзка между тригонометричните функции:

| | | |
|--------------------------------|---|---|
| | $\sin \alpha$ | $\cos \alpha$ |
| $\sin \alpha =$ | $\sin \alpha$ | (2.1): $\pm \sqrt{1 - \cos^2 \alpha}$ |
| $\cos \alpha =$ | (2.2): $\pm \sqrt{1 - \sin^2 \alpha}$ | $\cos \alpha$ |
| $\operatorname{tg} \alpha =$ | (2.3): $\frac{\sin \alpha}{\pm \sqrt{1 - \sin^2 \alpha}}$ | (2.4): $\frac{\pm \sqrt{1 - \cos^2 \alpha}}{\cos \alpha}$ |
| $\operatorname{cotg} \alpha =$ | (2.5): $\frac{\pm \sqrt{1 - \sin^2 \alpha}}{\sin \alpha}$ | (2.6): $\frac{\cos \alpha}{\pm \sqrt{1 - \cos^2 \alpha}}$ |

| | | |
|--------------------------------|---|--|
| | $\operatorname{tg} \alpha$ и $\operatorname{tg} \frac{\alpha}{2}$ | $\operatorname{cotg} \alpha$ |
| $\sin \alpha =$ | (2.7): $\frac{\operatorname{tg} \alpha}{\pm \sqrt{1 + \operatorname{tg}^2 \alpha}}$ (2.8): $\frac{2 \operatorname{tg} \frac{\alpha}{2}}{1 + \operatorname{tg}^2 \frac{\alpha}{2}}$ | (2.9): $\frac{1}{\pm \sqrt{1 + \operatorname{cotg}^2 \alpha}}$ |
| $\cos \alpha =$ | (2.10): $\frac{1}{\pm \sqrt{1 + \operatorname{tg}^2 \alpha}}$ (2.11): $\frac{1 - \operatorname{tg}^2 \frac{\alpha}{2}}{1 + \operatorname{tg}^2 \frac{\alpha}{2}}$ (2.12): $\cos^2 \frac{\alpha}{2} - \sin^2 \frac{\alpha}{2}$ | (2.13): $\frac{\operatorname{cotg} \alpha}{\pm \sqrt{1 + \operatorname{cotg}^2 \alpha}}$ |
| $\operatorname{tg} \alpha =$ | (2.14): $\frac{2 \operatorname{tg} \frac{\alpha}{2}}{1 - \operatorname{tg}^2 \frac{\alpha}{2}}$ (ВИЖ 16) | (2.15): $\frac{1}{\operatorname{cotg} \alpha}$ |
| $\operatorname{cotg} \alpha =$ | (2.16): $\frac{1}{\operatorname{tg} \alpha}$ | (2.17): $\frac{1 - \operatorname{tg}^2 \frac{\alpha}{2}}{2 \operatorname{tg} \frac{\alpha}{2}}$ (ВИЖ 16) |

3. Формули за понижаване на степен:

3.1: $2 \sin^2 \alpha = 1 - \cos 2\alpha$

3.2: $\sin^2 \alpha = \frac{1 - \cos 2\alpha}{2}$

3.3: $2 \cos^2 \alpha = 1 + \cos 2\alpha$

3.4: $\cos^2 \alpha = \frac{1 + \cos 2\alpha}{2}$

3.5: $4 \sin^3 \alpha = 3 \sin \alpha - \sin 3\alpha$

3.6: $4 \cos^3 \alpha = 3 \cos \alpha + \cos 3\alpha$

3.7: $8 \sin^4 \alpha = \cos 4\alpha - 4 \cos 2\alpha + 3$

3.8: $8 \cos^4 \alpha = \cos 4\alpha + 4 \cos 2\alpha + 3$

3.9: $\sin^4 \alpha - \cos^4 \alpha = \sin^2 \alpha - \cos^2 \alpha$

3.10: $\operatorname{cotg}^2 \alpha = \frac{1 - \sin 2\alpha}{1 + \sin 2\alpha}$

3.11: $2 \sin^2 \frac{\alpha}{2} = 1 - \cos \alpha$

3.12: $2 \cos^2 \frac{\alpha}{2} = 1 + \cos \alpha$

4. Формули за сбор и разлика на два ъгъла:

4.1: $\sin(\alpha \pm \beta) = \sin \alpha \cos \beta \pm \cos \alpha \sin \beta$

4.2: $\cos(\alpha \pm \beta) = \cos \alpha \cos \beta \mp \sin \alpha \sin \beta$

4.3: $\cos(\alpha + \beta) \cos(\alpha - \beta) = \cos^2 \beta - \sin^2 \alpha$

4.4: $\sin(\alpha + \beta) \sin(\alpha - \beta) = \sin^2 \alpha - \sin^2 \beta$

4.5: $\operatorname{tg}(\alpha \pm \beta) = \frac{\operatorname{tg} \alpha \pm \operatorname{tg} \beta}{1 \mp \operatorname{tg} \alpha \cdot \operatorname{tg} \beta}$

4.6: $\operatorname{cotg}(\alpha \pm \beta) = \frac{\operatorname{cotg} \alpha \cdot \operatorname{cotg} \beta \mp 1}{\operatorname{cotg} \beta \pm \operatorname{cotg} \alpha}$

5. Двойни, тройни и половинки ъгли:

5.1: $\sin 2\alpha = 2 \sin \alpha \cos \alpha = (\sin \alpha + \cos \alpha)^2 - 1$
(ВИЖ 17)

5.2: $\cos 2\alpha = \cos^2 \alpha - \sin^2 \alpha = \cos^4 \alpha - \sin^4 \alpha = 2 \cos^2 \alpha - 1 = 1 - 2 \sin^2 \alpha = \frac{1 - 4 \sin^2 \alpha \cdot \cos^2 \alpha}{\cos^2 \alpha - \sin^2 \alpha}$ (ВИЖ 1)

$= \frac{1 - \operatorname{tg}^2 \alpha}{1 + \operatorname{tg}^2 \alpha}$ (ВИЖ 15)

5.3: $\operatorname{tg} 2\alpha = \frac{2 \operatorname{tg} \alpha}{1 - \operatorname{tg}^2 \alpha} = \frac{2}{\operatorname{cotg} \alpha - \operatorname{tg} \alpha}$

5.4: $\operatorname{cotg} 2\alpha = \frac{\operatorname{cotg}^2 \alpha - 1}{2 \operatorname{cotg} \alpha} = \frac{\operatorname{cotg} \alpha - \operatorname{tg} \alpha}{2}$

5.5: $\sin 3\alpha = 3 \sin \alpha - 4 \sin^3 \alpha = \sin \alpha (3 - 4 \sin^2 \alpha) = \cos \alpha (2 \cos 2\alpha - 1) = \sin \alpha (4 \cos^2 \alpha - 1) = 4 \sin \alpha \sin(60^\circ + \alpha) \sin(60^\circ - \alpha) = 3 \cos^2 \alpha \sin \alpha - \sin^3 \alpha$ (ВИЖ 3)

5.6: $\cos 3\alpha = 4 \cos^3 \alpha - 3 \cos \alpha = \cos \alpha (4 \cos^2 \alpha - 3) = \cos \alpha (1 - 4 \sin^2 \alpha) = 4 \cos \alpha \sin(30^\circ - \alpha) \sin(30^\circ + \alpha) = \cos^2 \alpha - 3 \cos \alpha \sin^2 \alpha$ (ВИЖ 2)

5.7: $\operatorname{tg} 3\alpha = \operatorname{tg} \alpha \operatorname{tg}(60^\circ - \alpha) \operatorname{tg}(60^\circ + \alpha)$

5.8: $\operatorname{tg} 3\alpha = \frac{3 \operatorname{tg} \alpha - \operatorname{tg}^3 \alpha}{1 - 3 \operatorname{tg}^2 \alpha}$

5.9: $\operatorname{cotg} 3\alpha = \operatorname{cotg} \alpha \operatorname{cotg}(60^\circ - \alpha) \operatorname{cotg}(60^\circ + \alpha)$

5.10: $\operatorname{cotg} 3\alpha = \frac{\operatorname{cotg}^3 \alpha - 3 \operatorname{cotg} \alpha}{3 \operatorname{cotg}^2 \alpha - 1}$

5.11: $\cos 4\alpha = \cos^4 \alpha - 6 \cos^2 \alpha \sin^2 \alpha + \sin^4 \alpha$ (ВИЖ 2)

5.12: $\sin 4\alpha = 4 \cos^3 \alpha \sin \alpha - 4 \cos \alpha \sin^3 \alpha$ (ВИЖ 3)

5.13: $\sin \frac{\alpha}{2} = \pm \sqrt{\frac{1 - \cos \alpha}{2}}$

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$$5.14: \cos \frac{\alpha}{2} = \pm \sqrt{\frac{1 + \cos \alpha}{2}}$$

$$5.15: \operatorname{tg} \frac{\alpha}{2} = \pm \sqrt{\frac{1 - \cos \alpha}{1 + \cos \alpha}} = \frac{\sin \alpha}{1 + \cos \alpha} = \frac{1 - \cos \alpha}{\sin \alpha}$$

$$5.16: \cot g \frac{\alpha}{2} = \pm \sqrt{\frac{1 + \cos \alpha}{1 - \cos \alpha}} = \frac{\sin \alpha}{1 - \cos \alpha} = \frac{1 + \cos \alpha}{\sin \alpha}$$

$$5.17: \operatorname{tg} \left(\frac{\pi}{4} + \alpha \right) = \frac{\cos \alpha + \sin \alpha}{\cos \alpha - \sin \alpha}$$

6. Преобразуване на произведение в алгебричен сбор:

$$6.1: \sin \alpha \cdot \sin \beta = \frac{1}{2} [\cos(\alpha - \beta) - \cos(\alpha + \beta)]$$

$$6.2: \cos \alpha \cdot \cos \beta = \frac{1}{2} [\cos(\alpha - \beta) + \cos(\alpha + \beta)]$$

$$6.3: \sin \alpha \cdot \cos \beta = \frac{1}{2} [\sin(\alpha + \beta) + \sin(\alpha - \beta)]$$

$$6.4: \operatorname{tg} \alpha \cdot \operatorname{tg} \beta = \frac{\operatorname{tg} \alpha + \operatorname{tg} \beta}{\cot g \alpha + \cot g \beta} = -\frac{\operatorname{tg} \alpha - \operatorname{tg} \beta}{\cot g \alpha - \cot g \beta}$$

$$6.5: \cot g \alpha \cdot \cot g \beta = \frac{\operatorname{corg} \alpha + \cot g \beta}{\operatorname{tg} \alpha + \operatorname{tg} \beta} = \frac{\cot g \alpha - \cot g \beta}{\operatorname{tg} \alpha - \operatorname{tg} \beta}$$

$$6.6: \cot g \alpha \cdot \operatorname{tg} \beta = \frac{\cot g \alpha + \operatorname{tg} \beta}{\operatorname{tg} \alpha + \cot g \beta} = -\frac{\cot g \alpha - \operatorname{tg} \beta}{\operatorname{tg} \alpha - \cot g \beta}$$

7. Преобразуване на сбор или разлика в произведение:

$$7.1: \sin \alpha + \sin \beta = 2 \sin \frac{\alpha + \beta}{2} \cos \frac{\alpha - \beta}{2}$$

$$7.2: \sin \alpha - \sin \beta = 2 \sin \frac{\alpha - \beta}{2} \cos \frac{\alpha + \beta}{2}$$

$$7.3: \cos \alpha + \cos \beta = 2 \cos \frac{\alpha + \beta}{2} \cos \frac{\alpha - \beta}{2}$$

$$7.4: \cos \alpha - \cos \beta = -2 \sin \frac{\alpha + \beta}{2} \sin \frac{\alpha - \beta}{2}$$

$$7.5: \operatorname{tg} \alpha \pm \operatorname{tg} \beta = \frac{\sin(\alpha \pm \beta)}{\cos \alpha \cos \beta}$$

$$7.6: \cot g \alpha \pm \cot g \beta = \frac{\sin(\beta \pm \alpha)}{\sin \alpha \sin \beta}$$

8. Преобразуване във вид удобен за логаритмуване:

$$8.1: 1 + \sin \alpha = 1 + \cos(90^\circ - \alpha) = 2 \cos^2 \left(45^\circ - \frac{\alpha}{2} \right)$$

$$= \left(\cos \frac{\alpha}{2} + \sin \frac{\alpha}{2} \right)^2 \quad (\text{виж } 14)$$

$$8.2: 1 - \sin \alpha = 2 \sin^2 \left(45^\circ - \frac{\alpha}{2} \right)$$

$$8.3: 1 \pm \operatorname{tg} \alpha = \frac{\sin(45^\circ \pm \alpha)}{\cos 45^\circ \cos \alpha} = \frac{\sqrt{2} \sin(45^\circ \pm \alpha)}{\cos \alpha} \quad (\text{ВИЖ } 4.)$$

$$8.4: 1 \pm \operatorname{tg} \alpha \operatorname{tg} \beta = \frac{\cos(\alpha \mp \beta)}{\cos \alpha \cos \beta}$$

$$8.5: \cot g \alpha \cot g \beta \pm 1 = \frac{\cos(\alpha \mp \beta)}{\sin \alpha \sin \beta}$$

$$8.6: 1 - \operatorname{tg}^2 \alpha = \frac{\cos 2\alpha}{\cos^2 \alpha} \quad (\text{ВИЖ } 5)$$

$$8.7: 1 - \cot g^2 \alpha = -\frac{\cos 2\alpha}{\sin^2 \alpha}$$

$$8.8: A + B \sin \alpha = 2B \sin \frac{\alpha + \varphi}{2} \cos \frac{\alpha - \varphi}{2}, \text{ ако } \left| \frac{A}{B} \right| \leq 1, \sin \varphi = \frac{A}{B}$$

$$A - B \sin \alpha = 2B \sin \frac{\alpha - \varphi}{2} \cos \frac{\alpha + \varphi}{2}$$

$$8.9: C + D \cos \alpha = 2D \cos \frac{\alpha + \theta}{2} \cos \frac{\alpha - \theta}{2}, \text{ ако } \left| \frac{C}{D} \right| \leq 1, \cos \theta = \frac{C}{D}$$

$$E - F \cos \alpha = -2F \sin \frac{\alpha + \theta}{2} \sin \frac{\alpha - \theta}{2}, \text{ ако } \left| \frac{E}{F} \right| \leq 1, \cos \theta = \frac{E}{F}$$

$$8.10: \sin \alpha + \sin 2\alpha + \dots + \sin n\alpha = \frac{\cos \frac{\alpha}{2} - \cos \frac{(2n+1)\alpha}{2}}{2 \sin \frac{\alpha}{2}}$$

$$8.11: \cos \alpha + \cos 2\alpha + \dots + \cos n\alpha = \frac{\sin \frac{(2n+1)\alpha}{2} - \sin \frac{\alpha}{2}}{2 \sin \frac{\alpha}{2}}$$

$$8.12: \sin \alpha + \cos \alpha = \sqrt{2} \cos(45^\circ - \alpha) \quad (\text{ВИЖ } 7)$$

$$\sin \alpha + \cos \alpha = \sqrt{2} \sin(\alpha + 45^\circ)$$

$$8.13: \cos \alpha - \sin \alpha = \sqrt{2} \sin(45^\circ - \alpha)$$

$$\sin \alpha - \cos \alpha = \sqrt{2} \sin(\alpha - 45^\circ)$$

$$8.14: \operatorname{tg} \alpha + \cot g \beta = \frac{\cos(\alpha - \beta)}{\cos \alpha \sin \beta}; \operatorname{tg} \alpha - \cot g \beta = -\frac{\cos(\alpha + \beta)}{\cos \alpha \sin \beta}$$

$$8.15: 1 + \sin \alpha + \cos \alpha = 2\sqrt{2} \cos \frac{\alpha}{2} \sin \left(\frac{\alpha}{2} + 45^\circ \right) \quad (\text{ВИЖ } 6)$$

$$8.16: \sin \alpha + \sqrt{3} \cos \alpha = 2 \sin(\alpha + 60^\circ) \quad (\text{ВИЖ } 8)$$

$$8.17: \sin \alpha + \cos 3\alpha = 2 \sin(45^\circ - \alpha) \cos(2\alpha - 45^\circ) \quad (\text{ВИЖ } 9)$$

$$8.18: 3 \cos^2 \frac{\alpha}{2} - \sin^2 \frac{\alpha}{2} = 4 \cos \left(30^\circ + \frac{\alpha}{2} \right) \cos \left(30^\circ - \frac{\alpha}{2} \right)$$

(ВИЖ 10)

$$8.19: 4 \sin^2 \frac{\alpha}{2} - 1 = 4 \sin \left(\frac{\alpha}{2} + 30^\circ \right) \sin \left(\frac{\alpha}{2} - 30^\circ \right) \quad (\text{ВИЖ } 11)$$

$$8.20: 3 - 4 \sin^2 \alpha = \frac{\sin 3\alpha}{\sin \alpha} \quad (\text{ВИЖ } 13)$$

$$8.21: 3 - \operatorname{tg}^2 \alpha = \frac{\sin 3\alpha}{\sin \alpha \cos^2 \alpha}$$

$$8.22: \cot g^2 \alpha - 3 = \frac{\cos 3\alpha}{\cos \alpha \sin^2 \alpha}$$

$$8.23: \sin^2 \alpha - \sin^2 \beta = \cos^2 \beta - \cos^2 \alpha = \sin(\alpha + \beta) \sin(\alpha - \beta)$$

$$8.24: \cos^2 \alpha - \sin^2 \beta = \cos^2 \beta - \sin^2 \alpha = \cos(\alpha + \beta) \cos(\alpha - \beta)$$

$$8.25: \operatorname{tg}^2 \alpha - \operatorname{tg}^2 \beta = \frac{\sin(\alpha + \beta) \sin(\beta - \alpha)}{\cos^2 \alpha \cos^2 \beta}$$

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$$8.26: \cot g^2 \alpha - \cot g^2 \beta = \frac{\sin(\alpha + \beta) \sin(\beta - \alpha)}{\sin^2 \alpha \sin^2 \beta}$$

$$8.27: \operatorname{tg}^2 \alpha - \sin^2 \alpha = \operatorname{tg}^2 \alpha \sin^2 \alpha$$

$$8.28: \operatorname{cotg}^2 \alpha - \cos^2 \alpha = \operatorname{cotg}^2 \alpha \cos^2 \alpha$$

Преобразувания

$$1. \cos 2\alpha = \frac{\cos^2 2\alpha}{\cos 2\alpha} = \frac{1 - 1 + \cos^2 2\alpha}{\cos^2 \alpha - \sin^2 \alpha} = \frac{1 - (1 + \cos 2\alpha)(1 - \cos 2\alpha)}{\cos^2 \alpha - \sin^2 \alpha} = \frac{1 - 4 \frac{1 + \cos 2\alpha}{2} \frac{1 - \cos 2\alpha}{2}}{\cos^2 \alpha - \sin^2 \alpha} = \frac{1 - 4 \cos^2 \alpha \sin^2 \alpha}{\cos^2 \alpha - \sin^2 \alpha}$$

$$2. \cos n\alpha = \cos^n \alpha - C_n^2 \cos^{n-2} \alpha \sin^2 \alpha + C_n^4 \cos^{n-4} \alpha \sin^4 \alpha - \dots$$

$$3. \sin n\alpha = n \cos^{n-1} \alpha \sin \alpha - C_n^3 \cos^{n-3} \alpha \sin^3 \alpha + C_n^5 \cos^{n-5} \alpha \sin^5 \alpha - \dots$$

$$\text{където } C_n^k = \frac{n(n-1)(n-2)\dots(n-k+1)}{k!} = \frac{n(n-1)(n-2)\dots(n-k+1)}{1.2.3\dots k}$$

$$4. 1 + \operatorname{tg} \alpha = \operatorname{tg} 45^\circ + \operatorname{tg} \alpha = \frac{\sin 45^\circ}{\cos 45^\circ} + \frac{\sin \alpha}{\cos \alpha} = \frac{\sin 45^\circ \cos \alpha + \cos 45^\circ \sin \alpha}{\cos 45^\circ \cos \alpha} = \frac{\sin(45^\circ + \alpha)}{\frac{\sqrt{2}}{2} \cos \alpha} = \frac{\sqrt{2} \sin(45^\circ + \alpha)}{\cos \alpha}$$

$$5. 1 - \operatorname{tg}^2 \alpha = 1 - \frac{\sin^2 \alpha}{\cos^2 \alpha} = \frac{\cos^2 \alpha - \sin^2 \alpha}{\cos^2 \alpha} = \frac{\cos 2\alpha}{\cos^2 \alpha}$$

$$6. 1 + \sin \alpha + \cos \alpha = (1 + \cos \alpha) + \sin \alpha = 2 \cos^2 \frac{\alpha}{2} + 2 \sin \frac{\alpha}{2} \cos \frac{\alpha}{2} = 2 \cos \frac{\alpha}{2} \left(\sin \frac{\alpha}{2} + \cos \frac{\alpha}{2} \right) = 2\sqrt{2} \cos \frac{\alpha}{2} \left(\frac{\sqrt{2}}{2} \sin \frac{\alpha}{2} + \frac{\sqrt{2}}{2} \cos \frac{\alpha}{2} \right) =$$

$$= 2\sqrt{2} \cos \frac{\alpha}{2} \left(\sin \frac{\alpha}{2} \cos 45^\circ + \cos \frac{\alpha}{2} \sin 45^\circ \right) = 2\sqrt{2} \cos \frac{\alpha}{2} \sin \left(\frac{\alpha}{2} + 45^\circ \right)$$

$$7. \sin \alpha + \cos \alpha = \sin \alpha + \sin \left(\frac{\pi}{2} + \alpha \right) = 2 \sin \left(\alpha + \frac{\pi}{4} \right) \cos \frac{\pi}{4} = 2 \sin \left(\alpha + \frac{\pi}{4} \right) \frac{\sqrt{2}}{2} = \sqrt{2} \sin \left(\alpha + \frac{\pi}{4} \right)$$

$$8. \sin \alpha + \sqrt{3} \cos \alpha = 2 \left(\frac{1}{2} \sin \alpha + \frac{\sqrt{3}}{2} \cos \alpha \right) = 2 (\sin \alpha \cos 60^\circ + \cos \alpha \sin 60^\circ) = 2 \sin (\alpha + 60^\circ)$$

$$9. \sin \alpha + \cos 3\alpha = \sin \alpha + \sin(90^\circ - 3\alpha) = 2 \sin \frac{\alpha + 90^\circ - 3\alpha}{2} \cos \frac{\alpha - 90^\circ + 3\alpha}{2} = 2 \sin(45^\circ - \alpha) \cos(2\alpha - 45^\circ)$$

$$10. 3 \cos^2 \frac{\alpha}{2} - \sin^2 \frac{\alpha}{2} = 2 \cos^2 \frac{\alpha}{2} + \cos^2 \frac{\alpha}{2} - \sin^2 \frac{\alpha}{2} = 1 + \cos \alpha + \cos \alpha = 1 + 2 \cos \alpha = 4 \cos \left(30^\circ + \frac{\alpha}{2} \right) \cos \left(30^\circ - \frac{\alpha}{2} \right)$$

$$11. 4 \sin^2 \frac{\alpha}{2} - 1 = 2.2 \sin^2 \frac{\alpha}{2} - 1 = 2(1 - \cos \alpha) - 1 = 2 - 2 \cos \alpha - 1 = 1 - 2 \cos \alpha = 4 \sin \left(\frac{\alpha}{2} + 30^\circ \right) \sin \left(\frac{\alpha}{2} - 30^\circ \right)$$

$$13. \sin 3\alpha = 3 \sin \alpha - 4 \sin^3 \alpha \Leftrightarrow \sin 3\alpha = \sin \alpha (3 - 4 \sin^2 \alpha) \Leftrightarrow 3 - 4 \sin^2 \alpha = \frac{\sin 3\alpha}{\sin \alpha}$$

$$14. 1 + \sin \alpha = \sin^2 \frac{\alpha}{2} + \cos^2 \frac{\alpha}{2} + \sin 2 \frac{\alpha}{2} = \sin^2 \frac{\alpha}{2} + \cos^2 \frac{\alpha}{2} + 2 \cos \frac{\alpha}{2} \sin \frac{\alpha}{2} = \left(\sin \frac{\alpha}{2} + \cos \frac{\alpha}{2} \right)^2$$

$$15. \cos 2x = \cos^2 x - \sin^2 x = \frac{\cos^2 x - \sin^2 x}{\cos^2 x + \sin^2 x} = \frac{1 - \frac{\sin^2 x}{\cos^2 x}}{1 + \frac{\sin^2 x}{\cos^2 x}} = \frac{1 - \operatorname{tg}^2 x}{1 + \operatorname{tg}^2 x}$$

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$$16. \quad \operatorname{tg} x = \frac{\sin x}{\cos x} = \frac{\frac{2\operatorname{tg} \frac{x}{2}}{1 + \operatorname{tg}^2 \frac{x}{2}}}{\frac{1 - \operatorname{tg}^2 \frac{x}{2}}{1 + \operatorname{tg}^2 \frac{x}{2}}} = \frac{2\operatorname{tg} \frac{x}{2}}{1 + \operatorname{tg}^2 \frac{x}{2}}$$

$$17. (\sin x + \cos x)^2 - 1 = \sin^2 x + 2\sin x \cdot \cos x + \cos^2 x - 1 = 1 + 2\sin x \cdot \cos x - 1 = 2\sin x \cdot \cos x = \sin 2x$$

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