

Chapter 12 – Tangent (T, T₁, T₂ and ST scales)

It is an advantage to have two tangent scales (T₁, and T₂) on your Slide Rule, instead of just a single tangent scale (T). The T₁ and T scales are identical and used for angles between 5°44' and 45°, while the T₂ scale allows us to read directly angles greater the 45°. On the tangent scales the graduations in black are for tangents and those in red are for co-tangents, the latter reading from right to left.

12.1 Tangent (T₁ or T scale – for angles between 5°44' and 45°).

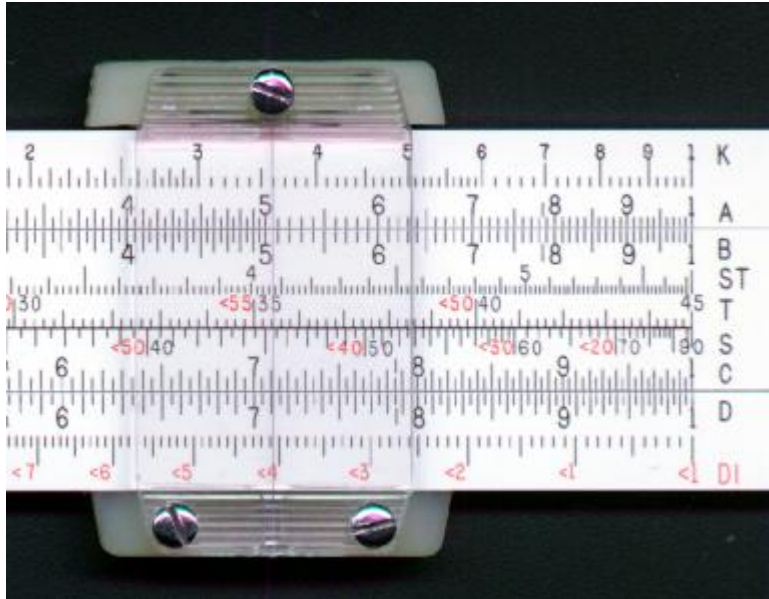


Fig 12-1

Example: $\tan 35^{\circ}24' = 0.71$ (Fig 12-1)

1. Set the hair line over 35°24' on the T₁ (or T) scale.
2. Under the hair line read off 0.71 on the D scale as the answer.

Exercise 12(a)

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|-----------------------------|------------------------------|
| (i) $\tan 31^{\circ} =$ | (iii) $\tan 15^{\circ}36' =$ |
| (ii) $\tan 44^{\circ}30' =$ | (iv) $\tan 8.7^{\circ} =$ |

12.2 Tangent (ST scale – for angles less than 5°44')

Less than 5 or 6 degrees, the sines and tangents of angles are the same at least to three figures of accuracy. Thus, the same scale will do for both (hence we call it the ST scale), and we find tangents of angles less than 5°44' in exactly the same way as we did for sine. (see fig 11.2)

Example 1: $\tan 4^{\circ}12' = 0.0733$

First convert 4°12' to 4.2°

1. Set the hair line over 4.2° on the ST scale.
2. Under the hair line read off 0.0733 on the D scale as the answer.

Note: For angles less than 0.573° (34') we use the procedures as outlined in 11.2.

Example 2: $\tan 0.42^{\circ} = 0.00733$

1. Set the hair line over 0.42 on the ST scale (i.e. at the point actually marked 4.2°).
2. Under the hair line read off 0.00733 on the D scale as the answer.

Exercise 12(b)

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|-------|-----------------------|------|----------------------|
| (i) | $\tan 4^{\circ}31' =$ | (iv) | $\tan 30' =$ |
| (ii) | $\tan 2.3^{\circ} =$ | (v) | $\tan 0.2^{\circ} =$ |
| (iii) | $\tan 0.79^{\circ} =$ | (vi) | $\tan 9' =$ |
| (vii) | | | |

12.3 Tangent (T₂ and T scale – for angles between 45° and 84°18’).

1. Using the T₂ Scale

With the T₂ scale the tangents of angles in this range can be directly read off as follows:

Example 1: $\tan 52^{\circ} = 1.28$

1. Set the hair line over 52° on the T₂ scale.
2. Under the hair line read off 1.28 on the D scale as the answer.

Note: The tangents of angles between 45° and 84°18’ are number between 1 and 10, hence, $\tan 52^{\circ}$ is read off on the D scale as 1.28.

2. Using the T or T₁ scale.

For a slide Rule without a T₂ scale, we can use the T scale because the $\tan \theta = \frac{1}{\tan(90-\theta)}$. (Note that

the T scale is identical with the T₁ scale.) This relationship can be proved using the fact that $\tan \theta = \frac{1}{\cot(90-\theta)}$ and $\tan \theta = \frac{1}{\cot \theta}$

$$\text{i.e. } \tan \theta = \frac{1}{\cot \theta} = \frac{1}{\tan(90-\theta)}$$

Thus to find $\tan 52^{\circ}$ we use the complement of 52° (i.e. 38°), and read the answer on the DI (or CI) scale instead of the D scale.

Example 2: $\tan 52^{\circ} = 1.28$

1. Set the hair line over 38° (the complement of 52°) on the T (or T₁) scale.
2. Under the hair line read off 1.28 on the DI (CI) scale as the answer.

Exercise 12(c)

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|-------|-----------------------|------|------------------------|
| (i) | $\tan 60^{\circ} =$ | (iv) | $\tan 82.5^{\circ} =$ |
| (ii) | $\tan 70^{\circ} =$ | (v) | $\tan 47^{\circ}45' =$ |
| (iii) | $\tan 63^{\circ}6' =$ | (vi) | $\tan 76^{\circ} =$ |
| (vii) | | | |

12.4 Tangent (ST scale – for angles greater than 84°18’).

Using $\tan \theta = \frac{1}{\tan(90-\theta)}$ we can obtain the tangents of angles greater than 84°18’ by finding their compliments on the ST scale and reading their value on the DI (or CI) scale.)

Example: $\tan 89.17^{\circ} = 69$.

1. Set the hair line over 0.83 (the compliment of 89.17°) on the ST scale.
2. Under the hair line read off 69 on the DI (or CI) scale as the answer.

Note: The tangents of angles between $84^{\circ}18'$ and 89.427° lie between 10 and 100.

Exercise 12(d)

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|-----------------------------|-----------------------------|
| (i) $\tan 85^{\circ} =$ | (iii) $\tan 89.1^{\circ} =$ |
| (ii) $\tan 87^{\circ}30' =$ | (iv) $\tan 88^{\circ}45' =$ |
| (v) | |

12.5 Cotangents

As $\cot \theta = \frac{1}{\tan \theta}$ we can find the cotangents of an angle by following the same procedures as we did for the tangents of the angle. If the tangent is read off the D (or C) scale the cotangent will be read off the DI (or CI) scale and visa-versa.

(Note: for small angles the cotangents are large, while the cotangents for angles near 90° are small.)

Example 1: $\cot 1^{\circ} = 57.3$.

1. Set the hair line over 1° on the ST scale.
2. Under the hair line read off 57.3 on the DI (or CI) scale as the answer.

Example 2: $\cot 39^{\circ}48' = 1.2$

(Express $39^{\circ}48'$ as 39.8°).

1. Set the hair line over 39.8° on the T_1 (or T) scale.
2. Under the hair line read off 1.2 on the DI (or CI) scale as the answer.

Example 3: $\cot 89^{\circ} = 0.1746$

Set the hair line on 1° on the ST scale.

Under the hair line read off 0.1746 on the D (or C) scale as the answer.

Exercise 12(e)

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|-----------------------------|------------------------------|
| (i) $\cot 37^{\circ} =$ | (v) $\cot 61^{\circ}20' =$ |
| (ii) $\cot 71^{\circ} =$ | (vi) $\cot 44' =$ |
| (iii) $\cot 4^{\circ}30' =$ | (vii) $\cot 22^{\circ}12' =$ |
| (iv) $\cot 87^{\circ} =$ | (viii) $\cot 89^{\circ}6' =$ |

12.6 Multiplication and Division with Tangents

The following table gives a few possible calculations involving tangents of angles up to $84^{\circ}18'$ using the ST, T_1 and T_2 scales located on the body of the Slide Rule. If your slide rule has only the ST and T scale these methods would have to be varied for angles greater 45° .

Note: In the following table T stand for whichever is appropriate of the ST, T_1 or T_2 scales (according to the size of the angle).

Exercise 12(f)

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|---|---|
| (i) $2.6 \tan 43^{\circ} =$ | (vii) $\pi \tan 39^{\circ} 24' =$ |
| (ii) $\frac{\tan 52^{\circ}}{0.45} =$ | (viii) $\frac{\tan 67^{\circ}36'}{\pi} =$ |
| (iii) $1.19 \tan 4^{\circ}30' =$ | (ix) $\sqrt{\pi} \tan 3.5^{\circ} =$ |
| (iv) $(6.3 \tan 17.2^{\circ})^2 =$ | (x) $\frac{\tan^2 23^{\circ}30'}{\pi} =$ |
| (v) $6.3 \tan^2 17.2^{\circ} =$ | |
| (vi) $\frac{1}{\tan^2 81^{\circ}30'} =$ | |

(In the following H.L. Stands for hair line.)

Example	Set HL Over	Under HL Place	Reset HL over	Under HL answer
$a \tan \theta$	θ on T scale	Index of C scale	A on C scale	On D scale
$\frac{\tan \theta}{a}$	θ T	a C	Index C	D
$\frac{a}{\tan \theta}$	θ T	a C	Index D	C
$(a \tan \theta)^2$	θ T	Index C	a C	A
$a \tan^2 \theta$	θ T	Index C	a B	A
$\frac{1}{\tan^2 \theta}$	θ T	Index C	Index A	B
$\pi \tan \theta$	θ T			DF
$\frac{\tan \theta}{\pi}$	θ T	π C	Index C	D
$\sqrt{\pi} \tan \theta$	θ T	Index C	π B	D
$\frac{\tan^2 \theta}{\pi}$	θ T	π B	Index B	A