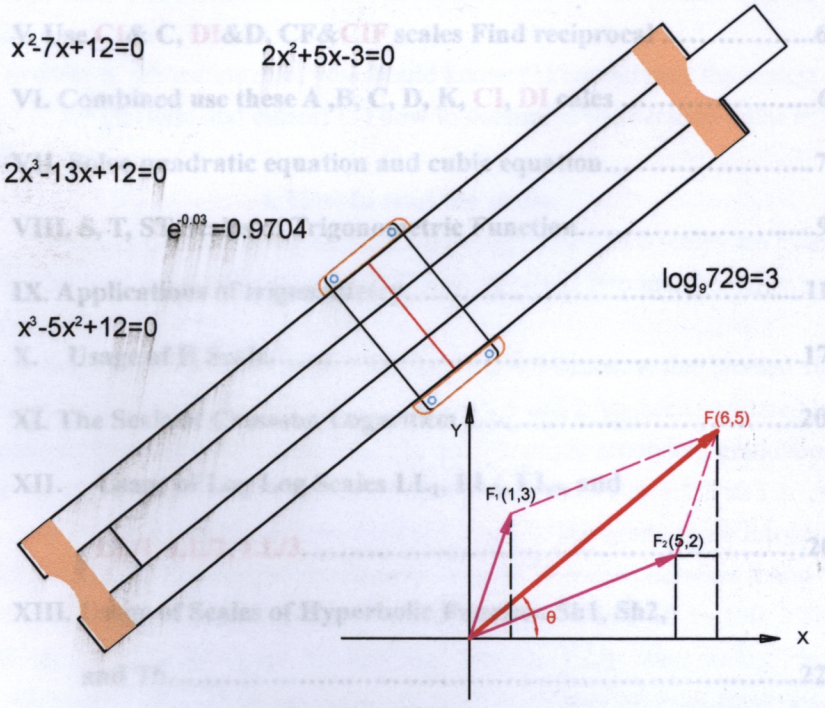
Flying Fish

TYPE 1015 Slide Rule

INSTRUCTION



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Instruction for The Use of
Flying Fish 1015 Slide Rule

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Introduction

The slide rule is a kind of tool that you can finding numerical answers to involved mathematical problems. It is very fast and easily to solve problems.

The slide rule consists of three parts: (1) The body (upper and lower fixed bars); (2) the slide; (3) the cursor or indicator. The scales on the body and slide are arranged to work together in solving problems. The hairline on the cursor is used to help the eyes in reading the scales and in adjusting the slide.

Each scale is named by letters or other symbol at the end. The 1015 slide rule, there are 13 scales on the side 1: LL/1, LL/2, LL/3, DF, CF, CIF, H, CI, C, D, LL3, LL2, LL1. There are 13 scales on side2 too: Sh1, Sh2, K, A, B, T, ST, S, C, D, DI, L Th

In order to use a slide rule, you should know: (1) how to read the scales; (2) how to "set the slide and cursor; (3) how to determine the decimal point in the result.

I. How to read the scales

The scales C and D are used most frequently. These two scales are exactly alike. The total length of the scales has been separated into many smaller parts by fine lines.

A line labeled 1 at the left end is called the **left index**. A line labeled 10 at the right end is called the **right index**. Between 1 and 2 has been separated into 10 parts by shorter lines. That is 1.1, 1.2, etc. These are secondary graduations. And the same, there are some tertiary graduations between 1.1 and 1.2. etc.. The graduations interval is at 0.01 between 1 and 2, The graduations interval is at 0.02 between 2 and 4, The graduations interval is at 0.05 between 4 and 10. On D or C scale, you can read 1 to 10, and, you can read 10 to 100, 100 to 1000, or, 0.1 to 1, and so on. By this way, you can judge other scales. Please pay attention to the red scales, some red scale is increasing from right to left, say, CI etc.

In the instruction, C:3 means the figure 3 on the C scale, DI:4.2 Means

the figure 4.2 on the DI scale, and so the rest.

II. Use C, D and CI Calculate Multiplication and Division

1. Use C, D scales calculate Multiplication

Ex: 2×4=? (8)

Set left index C:1 opposite D:2 (first factor), move hairline on C:4(Other factor), under hairline read D:8 is the Product.

Ex: 3×8=? (24)

Set right index C:10 opposite D:3 (first factor) [If set left index C:1 opposite D:3 (first factor), then, C:8(Other factor) out off body.] Move hairline on C:8(Other factor), under hairline read D:24 is the Product.

Multiplication

Ex: 2.5×7.2=? (18)

Move hairline on D:2.5, move slide set CI:7.2 under hairline. Opposite C:1 read D:18 is the Product.

3. Use CI, C, D scales calculate Continued Multiplication

Ex: 1.85×6.2×4.75=? (54.5)

Move hairline on D:1.85, move slide set **CI:6.2** under hairline. Temporality, C:1 opposite D:11.47 is the Product of 1.85×6.2. Remove hairline on C:4.75, under hairline read D:54.5 is the Product.

4. Use C, D scales calculate Division

Ex: 18÷3=?. (6)

Move hairline on D:18, move slide set C:3 under hairline. Opposite C:10 read D:6 is the Result.

Ex: 7.68÷4.8=?. (1.6)

Move hairline on D:7.68, move slide set C:4.8 under hairline. Opposite C:1 read D:1.6 is the Result.

5. Use CI, D scales calculate Division

Ex: 7.68÷4.8=?. (1.6)

Move slide set C:10 Opposite D:7.68, Move hairline on CI:4.8, under hairline read D:1.6 is the Result.

When dividend is fixed, divisor is change, use CI, D scales calculate Division, that is very convenient.

Ex: 96÷12=?. (8) 96÷19=? . (5.05). 96÷25.6=? (3.75)

Move slide set C:10 Opposite D:96, ordinal move hairline on CI:12, CI:19, CI:25.6, under hairline read D:8, D:5.05, D:3.75 are the Results.

6. Use CI, C and D scales calculate continued Division

Ex: 235÷3.8÷42=? (1.472)

move hairline on D:2.35, Move slide set C:3.8 under hairline, remove hairline on CI:42, under hairline read D:1.472 is the Results.

7. Use CI, C and D scales calculate combined continued multiplication and continued Division.

Ex: (3.8×6.9×7.5)÷(8.4×3.2)=? (7.32)

Move hairline on D:3.8, Move slide set C:8.4 under hairline (÷8.4). Remove hairline on C:6.9 (×6.9), Move slide set C:3.2 under hairline (÷3.2). Remove hairline on C:7.5 (×7.5), under hairline read D:7.32 is the Results.

Ex: (28.7×5.35)÷(4.3×2.9×8.05)=? (1.53)

Move hairline on D:28.7, Move slide set C:4.3 under hairline (÷4.3). Remove hairline on C:5.35 (×5.35), Move slide set C:2.9 under hairline (÷2.9). Remove hairline on CI:8.05 (÷8.05), under hairline read D:1.53 is the Results.

III. The A and B scales: Square roots and squares

The A and B scales are the squares of C and D scales. As the contrary, C and D scales is the square roots of A and B scales. Opposite D:n on A scale is n^2, contrarily, Opposite A:n on D scale is $n^{1/2}$.

1. Find Squares

Ex: 278^2=? (77300)

The hairline on the left sect of A scale	The hairline on the right sect of A scale
Digits of power=digits of factor × 2 -1	digits of power=digits of factor × 2

Move hairline on D:2.78, under hairline read A:7.73. Before you give the answer, you should determine the digits of the number. 278 is 3 places, hairline on the left sect of A scale , 3×2-1= 5, Power should be 5 places.

Ex: 0.0565^2=? (0.00319)

Move hairline on D:5.65, under hairline read A:31.9. 0.0565 is –1 place, The hairline on the right sect of A scale, (-1) ×2= -2,

2. Square Roots

In general, to find the square root of any number with an odd number of digits or zero (1,3,5,7,…), the left half of the A scale is used. And the digits of root=(digits of number +1) ÷ 2.

If the number with an even number of digits or zero (2,4,6,8,…), the right half of the A scale is used. And the digits of root=digits of number ÷ 2.

Ex: $\sqrt{30{,}000} = ?$ (173.2)

30,000 is a 5 digits odd number, so, move the hairline on A:3 at left half of the A scale, read D:1.732 under hairline. (5+1) ÷ 2.=3, the digits of root is 3.

Ex: $\sqrt{0.000585} = ?$ (0.0242)

0.000585 is a -3 digits odd number, so, move the hairline on A:5.85 at left half of the A scale, read D:2.42 under hairline. (-3+1) ÷ 2.= -1, the digits of root is -1.

Ex: $\sqrt{5300} = ?$ (72.8)

5300 is a 4 digits even number, so, move the hairline on A:53 at right half of the A scale, read D:7.28 under hairline. 4 ÷ 2.= 2, the digits of root is 2.

IV. The K scale: Cube roots and Cubes

The K scale is the cube of C and D scales. As the contrary, C and D scales are the cube roots of K scale. The K scale has 3 sects of same parts. First sect is 1-10, second sect is 10-100, third sect is 100-1000. Move hairline on D:n, read the number on K scale under hairline is n^3, contrarily, Opposite K:n on D scale is $\sqrt[3]{n}$.

1. Find Cubic

When find the power of cube, the way that determine the digits of the number is as follow,

(1) Hairline on the 1st sect of K scale, the digits of power=digits of factor ×3-2.

(2) Hairline on the 2nd sect of K scale, the digits of power=digits of factor ×3-1.

(3) Hairline on the 3rd sect of K scale, the digits of power=digits of factor ×3

Ex: $252^3 = ?$ (16000000)

Move the hairline on D:2.52, read K:16 under hairline. Hairline on the 2nd sect of K scale, so, the digits of power is 3×3-1=8

Ex: $0.0575^3 = ?$ (0.00019)

Move the hairline on D:5.75, read K:190 under hairline. Hairline on the 3rd sect of K scale, so, the digits of power is (-1)×3=-3

2. Find Cube Roots

When find the **cube roots,** to decide which part of the K scale to use in locating a number, mark off the digits in groups of three starting from the decimal point. If the left group contains one digit, the left third of K scale is used; If the left group contains two digits, the middle third of K scale is used; If there are three digits in the left group, the right third of K scale is used. In other words, numbers containing 1,4,7,… digits are located on the left third; numbers containing 2,5,8,… digits are located on the middle third; and numbers containing 3,6,9,… digits are located on the right third of the K scale. The root digits of integral is equal the number of groups of integral. The pure decimal fraction how many number of groups all in 0, the root has the number "0" after the decimal point.

Ex: $\sqrt[3]{89600} = ?$ (44.8)

89600 can mark off 89'600, the left group contains two digits, so, use the middle third find the answer. Move the hairline on K:89.6 of the 2nd sect of K scale, read D:4.48 under the hairline on D scale. The integral is in 2 groups, so, the integral digits of the root is 2.

Ex: $\sqrt[3]{0.00763} = ?$ (0.196)

0.00763 can mark off 0.007'630, the left group contains 1 digits, so, use

the left third find the answer. Move the hairline on K:7.63 of the 1st sect of K scale, read D:1.969 under the hairline on D scale. The all in 0 groups is 0 group, so, the root is in 0 digits.

V. Use CI& C, DI&D, CF&CIF scales Find reciprocal

CI scale is reciprocals of C scale; DI scale is reciprocals of D scale; CIF scale is reciprocals of CF scale. CI, DI and CIF are increasing from right to left. Put the hairline on C:n, read the CI:1/n under the hairline directly. Same way use DI and D scales, or CF and CIF scales.

Ex: 1/25=? (0.04)

Move hairline on C:2.5, Read CI:4 under hairline is the answer.

Ex: 1/0.0356=? (28.1)

Move hairline on C:3.56, Read CI:2.81 under hairline is the answer.

Use DI&D, CF&CIF scales can find the same answers for above.

VI. Combined use these A ,B, C, D, K, CI, DI scales

Ex: $5.1^{3/2}$=? (11.5)

$5.1^{3/2}=(5.1^{3})^{1/2}$

Move hairline on A:5.1, Read K:11.5 under hairline is the answer.

Ex: $125^{2/3}$=? (25)

$125^{2/3}=(125^{1/3})^{2}=5^{2}$

Move hairline on K:125, Read A:25 under hairline is the answer.

Ex: $3\times2^{1/2}$=? (4.24)

Pull slide set B:1 opposite A:2, Move hairline on C:3, read D:4.24 under hairline is the answer.

Ex: 4.35×1.25^{2}=? (6.8)

Pull slide set C:1 opposite D:1.25, Move hairline on B:4.35, read A:6.8 under hairline is the answer.

Ex: $2.76\times5.25^{1/3}$=? (4.8)

Move hairline on K:5.25, Pull slide set C:1 opposite K:5.25, remove hairline on C:2.76, read D:4.8 under hairline is the answer.

Ex: 3.45×4.25^{3}=? (265)

Move hairline on K:3.45, Pull slide set C:1 opposite K:3.45, remove hairline on C:4.25, read K:265 under hairline is the answer.

Ex: $1/2.44^{2}$=? (0.168)

Move hairline on DI:2.44, read A:16.8 under hairline, 0.168 is the answer.

Ex: $1/17.8^{1/2}$=? (0.237)

Move hairline on A:17.8, read DI:2.37 under hairline, 0.237 is the answer.

Ex: $1/6.15^{3}$=? (0.0043)

Move hairline on DI:6.15, read K:4.3 under hairline, 0.0043 is the answer.

Ex: $1/23.5^{1/3}$=? (0.349)

Move hairline on K:23.5, read DI:3.49 under hairline, 0.349 is the answer.

Ex: $8.65/1.88^{2}$=? (2.45)

Move hairline on A:8.65, Pull slide set C:1.88 opposite A:8.65, read A:2.45 opposite B:1, 2.45 is the answer.

Ex: $3.66^{2}/25.5$=? (0.525)

Move hairline on D:3.66, Pull slide set B:25.5 opposite D:3.66, read A:52.5 opposite B:100, 0.525 is the answer.

Ex: $54/2.33^{3}$=? (4.26)

Move hairline on K:54, Pull slide set C:2.33 opposite K:54, remove hairline on B:1, read K:4.26 under hairline, 4.26 is the answer.

VII. Solve quadratic equation and cubic equation

1. For quadratic equation $X^2+PX+q=0$

If X_1, X_2 are the two roots of the equation, then, $X_1+X_2=-P$, $X_1\times X_2=q$. Pull the slide, set D:1 opposite C:q, then, no matter where the hairline moved on, The product of the two number on C and DI scales under hairline as the two factors. So, choose two number make the sum of them equals –P, the two number are the X_1, X_2.

Ex: $X^2-7X+12=0$ Find X=?

Pull the slide, set D:1 opposite C:1.2, move the cursor gradually, choose two number on C and DI scales make the sum equals 7. For this equation, the hairline is on C:3 and DI:4, further more 3+4=7, so,

$X_1=3$, $X_2=4$

Ex: $X^2-2X-15=0$ Find X=?

Pull the slide, set D:1 opposite C:1.5, move the cursor gradually, choose two number on C and DI scales make the sum equals 2. For this equation, the constant –15 is a negative, so, one root of the two will be a negative. The hairline is on C:3 and DI:5, further more (-3)+5=2, so,

$X_1=-3$, $X_2=5$

Ex: $X^2+5X-9=0$ Find X=?

For this equation, the constant –9 is a negative, so, the two roots should be a negative and a positive. Pull the slide, set D:10 opposite C:9, move the cursor gradually, can get the follow groups number

C scale	1	1.125	1.286	1.385	1.5	
DI scale	-9	-8	-7	-6.5	-6	
Sum	-8	-6.875	-5.714	-5.115	-4.5	

The sum of 1.385 and –6.5 is -5.115 which approaches the –5, so, the two number 1.385 and –6.5 nearly are the roots, move the cursor a little left, the hairline is on C:1.405 and DI:-6.405, further more 1.405+(-6.405)= -5,

so, X_1= 1.405, X_2= -6.405 are the roots.

2. For quadratic equation $aX^2+bX+c=0$,

The c **equation** an change it into $X^2+b/aX+c/a=0$, then, solve it by the way on above

3. For cubic equation $X^3+NX^2+PX+q=0$,

When N (coefficient of simple term) or P (coefficient of quadratic term) is equal zero, can use the way that be used on quadratic equation.

Ex: $X^3-13X+12=0$

It equal $X^2+12/X=13$

Pull the slide, set D:1 opposite C:12, move cursor, no matter hairline on any place, Use the C scale under hairline as the X, then, the number on DI scale is 12/X, the number on B scale is X^2. So, when move the cursor slowly, as long as the sum of the number on B scale and on the DI scale is equal 13, the number on C scale under hairline is one root. For this Ex, when the hairline on C:3, A scale on 9, DI scale on 4,

9+4=13, so, $X_1=3$

when the hairline on C:4, A scale on 16, DI scale on 3,

16-3=13, so, $X_2=-4$

For this cubic equation, as the P is "0", so $X_1+X_2+X_3=0$

$3-4+X_3=0$ $X_3=1$

The three roots: $X_1=3$, $X_2=-4$, $X_3=1$

Ex: $X^3-5X^2+12=0$ i.e. $X+12/X^2=5$

Pull slide, set A:1 opposite B1.2(12). Move cursor, then under hairline, the number on DI is X, the number on B is $12/X^2$.

DI scale	10	5	4	4.37	2	
B scale	0.12	0.48	0.75	0.63	3	
Sum	10.12	5.48	4.75	5	5	

$X_1=4.37$, $X_2=2$.

For this cubic equation, $X_1X_2X_3=-12$, i.e. $4.37\times2\times X_3=-12$ $X_3=-1.373$

The three roots: $X_1=4.37$, $X_2=2$, $X_3=-1.373$

VIII. S, T, ST Scales of Trigonometric Function

Type 1015 Slide rule provides 3 scales of trigonometric functions of angles, i.e. T, S and ST. It should be noted that black figures marked on the scales represent computations for the positive functional angles, while red figures represent those for the complementary functional angles. Set the hairline directly over any angles x on the scale of trigonometric function, read answer on C scale under the hairline, this is precisely the functional value.

1. Use S and C scales.

(1) Find sinθ

Use S and C scales. S scale from 5.5° to 90°, Let the number on C scale be divided by 10, move the cursor, under the hairline the number on C scale opposite the S scale will be the answer of sinθ.

Ex: sin30°=? Sin42°=?

Move hairline on S:30, read the C:0.5 under hairline is the answer;

Move hairline on S:42, read the C:0.682 is the answer.

(2) Find $\sin^{-1}x$

Ex: sinθ=0.286, find θ=?, (16.6°).

As the contrary, move hairline on C:0.286, read the S:16.6 is the answer.

(3) Find cosθ,

cosθ=sin(90° - θ), The S scale from left to right, it is marked by black number, for find sinθ; from right to left, it is marked by red number.

(4) for find cosθ.

Ex: cos60°=? (0.5)

Move hairline on S:60(red), read the C:0.5 under hairline is the answer.

2. Use T scale find tgθ and ctgθ

Use T scale. T scale from left to right marked 5.5° to 45° for Find tgθ of 5.71° to 45°, From right to left marked red 45° to 84.5° for Find ctgθ of 45° to 84.29°. As ctgθ=1/tgθ, so, use T scale combine with DI or CI scale, can find tgθ of 45° to 84.29° and ctgθ of 5.71° to 45°.

(1) Find tgθ,

Ex: tg12.4°=?

Move hairline on T:12.4°, read the C:0.22 under hairline is the answer.

Ex: tg60°=?

Move hairline on T:60°, read the DI:1.732 under hairline is the answer.

(2) Find ctgθ,

Ex ctg15°=?

ctg15°=1/tg15°, Move hairline on T:15°, read the DI:3.73 under hairline is the answer.

Ex: ctg82°=?

ctg82°=1/tg82°, Move hairline on T:82°, read the C:0.1405 under hairline is the answer.

3. Use ST scale find sinθ and tgθ for small angles of 0.573° ~5. 73°

When the angle is very small, sinθ is about equal tgθ, and, it is about equal radian of θ. So, use ST scale combine with C scale, can find sinθ and tgθ for small angles of 0.573° ~5.73° , meanwhile, can find cosθ and ctgθ for angles of 84.27° ~89.427° . But, must pay attention, the number on C scale should be divided by 100. If the ST scale combine with DI scale, the number on DI scale should be multiple by 10.

Ex: sin1.5°=tg1.5°=?

Move hairline on ST:1.5, read the C:0.0262 under hairline is the answer.

Ex: ctg1.5°=?

As ctg1.5°=1/tg1.5°, Move hairline on ST:1.5, read the DI:38.2 under hairline is the answer.

Ex: cos87°=?

As cos87°=sin3°, Move hairline on ST:3, read the C:0.0532 under hairline is the answer.

Ex: tg88°=?

As tg88°=ctg2°= 1/tg2°, Move hairline on ST:2, read the DI:28.6 under hairline is the answer.

Ex: ctg88.5°=?

As ctg 88.5°=tg1.5°, Move hairline on ST:1.5, read the C:0.0262 under hairline is the answer.

IX. Applications of trigonometry

The use of trigonometric function values in finding the length of the sides and size of the angles of triangles.

1. Solving the right triangle

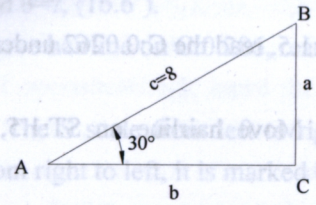
(1) One of the Methods in solving the right triangle is using the Law of Sines. When known the size of an acute angle and the length of the opposite side of the right triangle, or, known the lengths of a right angle side and hypotenuse, the law of sines can be used.

The relational expression is as follows:

$$\frac{a}{\sin A}=\frac{b}{\sin B}=\frac{c}{\sin C} \quad \text{Or} \quad \frac{\sin A}{a}=\frac{\sin B}{b}=\frac{\sin C}{c}$$

For Ex, A triangle, known the size of angle A is 30° , the length of hypotenuse c is 8, find the size of angle B, and the lengths of sides a and b.

∠B=90° -∠A=60° ,using the law of sines.



$$\frac{\sin 90}{8}=\frac{\sin 60}{b}=\frac{\sin 30}{a}$$

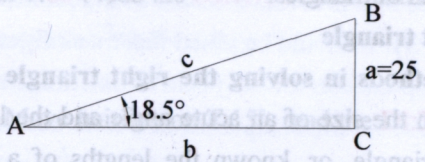
Move the slide left until S:90° (C:10) exactly against D:8, then set the hairline over S:60°, read the D:6.93 under hairline is b, then move the hairline over S:30°, read the D:4 under hairline is the a.

i.e. b=6.93, a=4

For Ex, A triangle, known the size of angle A is 18.5°, the length of a is 25, find the size of angle B, and the lengths of sides c and b.

∠B=90° -∠A=71.5°

Using the law of sines: $\frac{\sin 18.5°}{25}=\frac{\sin 90°}{c}=\frac{\sin 71.5°}{b}$



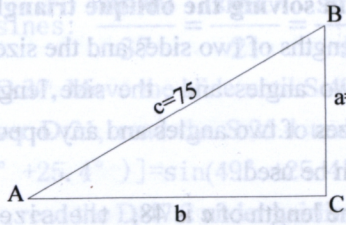
Set the hairline over D:25, move the slide left until S:18.5° exactly under the hairline, then the S:90° against D:78.75 is c, then move the hairline over S:71.5°, read the D:74.7 under hairline is the a.

i.e. c=78.75, b=74.7

Ex, A triangle, known the length of hypotenuse c is 75, the length of a is 36.4, find the sizes of ∠A and ∠B, and the lengths of side b.

Using the law of sines: $\frac{\sin 90}{75}=\frac{\sin A}{36.4}=\frac{\sin B}{b}$

Move the slide left until S:90° against D:75, set the hairline over D:36.4,

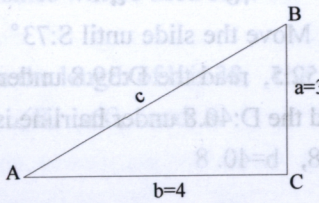


read the S:29 under hairline is the ∠A and its complementary angle S:61° is ∠B. Move the hairline over S:61°, read the D:65.6 under hairline is the b.

i.e. ∠A=29°, ∠B=61°, b=65.6

(2) Another method that using the Law of Sines in solving the right triangle. When known the the lengths of the two sides of the right triangle, the DI, T and S scales will be used.

Ex: A triangle, known the length of a is 3, the length of b is 4, find the sizes of ∠A and ∠B, and the lengths of side c.



Using the law of sines: $\frac{c}{\sin 90}=\frac{3}{\sin A}=\frac{4}{\sin B}$

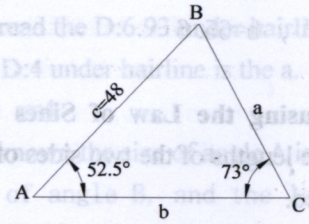
Set the hairline over DI:3, Move the slide left until T:45° under the hairline, move the hairline over DI:4, read the T:36.9 under hairline is the ∠A and its complementary angle T:53.1° is ∠B. Move the hairline over S:36.9°, read the DI:5 under hairline is the c.

i.e. ∠A=36.9°, ∠B=53.1°, c=5

2. Solving the oblique triangle

(1) One of the Methods in solving the oblique triangle is using the Law of Sines. When known the lengths of two sides and the size of the opposite angle, or known the sizes of two angles and the side length include of the two triangles, or known the sizes of two angles and any opposite side length of two angle , the law of sines can be used.

Ex, A triangle, known the length of c is 48, the sizes of ∠A is 52.5°, and ∠B is 73°, find ∠B, b, and a.



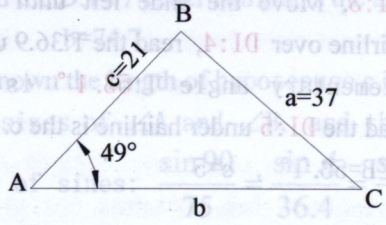
∠B=180° −(52.5° + 73°)=54.5°

Using the law of sines: $\frac{\sin 73}{48}=\frac{\sin 52.5}{a}=\frac{\sin 54.5}{b}$

Set the hairline over D:48, Move the slide until S:73° under the hairline, move the hairline over S:52.5, read the D:39.8 under hairline is a, Move the hairline over S:54.5° , read the D:40.8 under hairline is b.

i.e. ∠B=54.4° , a=39.8, b=40.8

Ex, A triangle, known the length of a is 37, the length of c is 21, and ∠B is 49°, find ∠B, ∠C, and b.



Using the law of sines: $\frac{\sin 49}{37}=\frac{\sin C}{21}=\frac{\sin B}{b}$

Set the hairline over D:37, Move the slide until S:49° under the hairline, move the hairline over D:21, read the S:25.4 under hairline is ∠C. since sinB=sin[180° −(49° +25.4°)]=sin(49° +25.4°)=sin74.4°. Move the hairline over S:74.4° , read the D:47.2 under hairline is b.

∠B=180° −(49° +25.4°)=105.6°

i.e. ∠B=105.6° , ∠C=25.4° , b=47.2

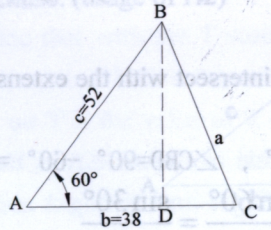
(2) Another methods in solving the oblique triangle. using the Law of sines. When known the lengths of two sides and the size of the include angle, the law of cosines can be used.

The relational expression is as follows:

1. $a^2=b^2+c^2-2bc\ \cos A$
2. $b^2=a^2+c^2-2ac\ \cos B$
3. $c^2=a^2+b^2-2ab\ \cos C$

But, it is not convenient using the law of cosines actually. So, in this case the law of sines will be used still.

Ex: A triangle, known the length of b is 38, the length of c is 52, and ∠A is 60° , find ∠B, ∠C, and a.



Draw a vertical line from B and intersect with AC at D.

Using the law of sines: $\frac{\sin 90°}{52}=\frac{\sin 60°}{BD}=\frac{\sin(90°-60°)}{AD}$.

Move the slide until S:90° against the D:52, Set the hairline over S:30°, read the D:26 under the hairline is AD, move the hairline over S:60°, read the D:45 under hairline is BD.

DC=38-26=12

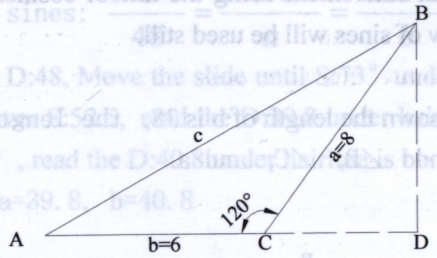
In the right triangle BCD, Known two right sides, can find ∠C and a using the second method for solving right triangle of above.

Set the hairline over DI:12, Move the slide left until T:45° under the hairline, move the hairline over DI:45, read the T:14.94 under hairline is the ∠CBD and its complementary angle T:75.06° is ∠C. Move the hairline over S:14.94°, read the DI:46.5 under hairline is the a.

∠B=(90°-60°)+14.94°=44.94°

i.e. ∠B=4.94°, ∠C=75.06°, a=46.5

Ex A triangle, known the length of a is 8, the length of b is 6, and ∠C is 120°, find ∠A, ∠B, and C.



Draw a vertical line from B and intersect with the extension line of AC at D. Then,

∠BCD=180°-120°=60°, ∠D=90°, ∠CBD=90°-60°=30°.

Using the law of sines: $\frac{\sin 90°}{8}=\frac{\sin 60°}{BD}=\frac{\sin 30°}{CD}$

Move the slide until S:90° against the D:8, Set the hairline over S:60°, read the D:6.93 under the hairline is BD, move the hairline over S:30°, read the D:4 under hairline is CD.

AD=AC+CD=6+4=10

Set the hairline over DI:6.93, Move the slide right until C:1 under the hairline, move the hairline over DI:1, read the T:34.7° under hairline is the ∠A. Move the hairline over S:34.7°, read the 12.17 on DI under hairline is the c. ∠B=180°-(A+C)=25.3°

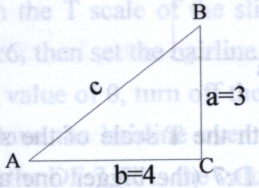
i.e. ∠A=34.7°, ∠B=25.3°, c=12.17.

X. Usage of H Scale

The graduation on H are engraved according to $\sqrt{1+(0.1C)^2}$. When hairline is over the H:1.044, it is also over the C:0.3, moreover, $1+0.3^2=1.044^2$. When hairline is over the H:1.25, it is also over the C:0.75, moreover, $1+0.75^2=1.25^2$. Since $1+tg^2\theta=sec^2\theta$, $1+ctg^2\theta=csc^2\theta$, when the hairline is over the T:30° (other side), the number 0.577 on C scale is the value of tg30°, the 1.155 on H scale is the value of sec30°. The values of secant from 5.71°~45° can be found in this way. Invert the rectangular coordinates into polar coordinates or otherwise, find the vectors compound sum, for finding the two acute angles and hypotenuse when known the right sides of a right triangle, this scale can be used.

1. Solving of right triangle.

Ex: A right triangle, known the base line is 4, opposite line is 3, find base angle and hypotenuse. (usage of H2)

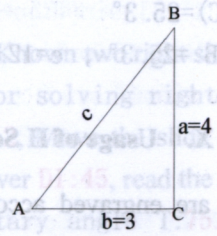


Use another side that with the S, T scale of the slide rule, move the slide left until C:10 exactly against D:4, then set the hairline over D:3, under the same hairline read the **36.9° on T** is the value of base angle, turn off the rule to the side with H, under the same place hairline can read the 1.25 on H, move

the hairline over CF:1.25, read the DF:5 under hairline is the hypotenuse.

i.e. ∠A=36.9°, c=5.

Ex: A right triangle, known the base side is 3, opposite side is 4, find the base angle and hypotenuse.

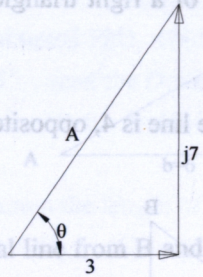


Use the side that with the T scale of the slide rule, move the slide left until C:10 exactly against D:4, then set the hairline over D:3, under the hairline read the **53.1° on T** is the value of base angle, turn off the rule to the side with H, under the same place hairline can read the D:5 is the hypotenuse.

i.e. ∠A=53.1°, c=5.

2. Solving of Vectors

Ex: Invert 3+j7 into polar coordinates.



Use the side that with the T scale of the slide rule, move the slide left until C:10 exactly against D:7 (the bigger one among 3 and 7), then set the hairline over D:3, under the hairline read the **66.8° on T** is the value of θ, turn off the rule to the side with H, the hairline is over H:1.088. i.e. secθ=1.088. Move the hairline over the 1.088 on CF, under the same place hairline can read the DF:7.62, i.e. 7sec23.2°=7.62.

i.e. 3+j7=7.62∠66.8°

Ex: Invert 5∠36.9° into rectangular coordinates.

Use the side that with the T scale of the slide rule, move the slide left until C:10 exactly against D:5, then set the hairline over S:53.1° (90°−36.9°), under the hairline read the D:4, i.e. a=5cos36.9°=4. set the hairline over S:36.9°, under the hairline read the D:3, i.e. a=5sin36.9°=3.

i.e. 5∠36.9°=4+j3.

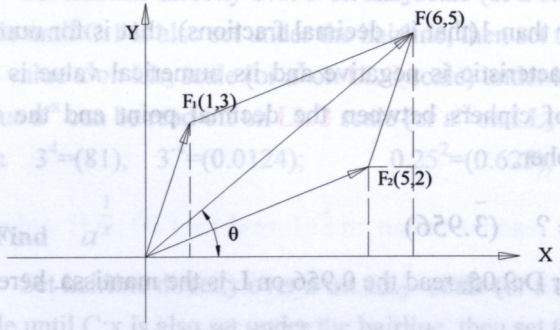
3. Find the Composition of Two Vectors

Ex: Known two force F_1 and F_2 act at one point, the projections are X_1=1, Y_1=3, X_2=5, Y_2=2. find the Composition force F and the direction angle θ.

Suppose X and Y are the projections of F,

Then $X=X_1+X_2=6$

$Y=Y_1+Y_2=5$



Use the side that with the T scale of the slide rule, move the slide left until C:10 exactly against D:6, then set the hairline over D:5, under the hairline read the 39.8° **on T** is the value of θ, turn off the rule to the side with H, the hairline is over H:1.302. Move the hairline over the 1.302 on CF, under the same place hairline can read the DF:7.82 is the value of F.

i.e. F=7.82∠39.8°

Ex: Known two force F_1 (5∠60°) and F_2 (9∠10°) act at one point. Find the Composition force F and the direction angle θ.

Suppose X and Y are the projections of F,

Then X= 5cos60° + 9cos10° =11. 36

Y= 5sin60° + 9sin10° =5. 892

Solve it as above Example get F=12.79∠27. 4° .

XI. The Scale of Common Logarithm L

The L scale is used to find common logarithm to the base 10, which is used to determine the mantissa of the logarithm of any given number. For prefixing the characteristic to the mantissa for 1 and all numbers greater than 1, the characteristic is one less than the number of place to the left of the decimal point in the given number. (that is, decimal fractions),

Ex: find lg25=? (1.699)

Set the hairline over D:25, read the 0.398 on L is the mantissa. here the characteristic is (2-1=1).

For numbers smaller than 1(that is, decimal fractions), that is for number wholly decimal, the characteristic is negative and its numerical value is one more than the number of ciphers between the decimal point and the first decimal which is not a cipher.

Ex: find $\lg 0.00905 = ?$ $(\bar{3}.956)$

Set the hairline over D:9.05, read the 0.956 on L is the mantissa. here the characteristic is (-2-1=-3).

XII. Usage of Log Log Scales LL_1, LL_2, LL_3, and LL/1, LL/2, LL/3

1. Find Reciprocals

The scales LL_1 and LL/1 are reciprocals scales to each other, and so are LL_2 and LL/2, LL_2 and LL/3.

For example, set hairline directly over **LL_3:10,** read off the **LL/3:0.1** is the reciprocal.

2. Find the natural logarithm having positive characteristics or for a real number which is larger than 1.

Set hairline directly over any real number **X** on scales **LL_1, LL_2, LL_3,** then read the value **LnX** on **D** scale under hairline.

For example:

Ln20.1=(3), Set fairline over LL_3:20.1, Read D:3 under hairline.

Ln1.6=(0.47), Set fairline over LL_2:1.6, Read D:4.7 under hairline. When use LL_2 and D, The number on D should divide by 10).

Ln1.032=(0.0315) , Set fairline over LL_1:1.032, Read D:3.15 under hairline. When use LL_1 and D, The number on D should divide by 100).

3. Find the natural logarithm having negative characteristics or for a real number which is smaller than 1.

Set hairline directly over any real number **Y** on scales **LL/1, LL/2, LL/3,** then read the value **LnY** on **D** scale under hairline.

Ex: Ln0.0497=(-3), Ln0.67=(-0.4), Ln0.9608=(-0.04)

4. Find a^x

Set hairline directly over **a** on **LL_3** scale (or a on **LL/3** scale), move the slide until C:1 is also set under the hairline, then set the hairline over C:x, read the value a^x on LL_3 scale (or a^x on LL/3 scale) under hairline. Meanwhile, the value a^{-x} can be read off on LL/3 scale (or a^{-x} on LL_3 scale) under hairline.

Ex: 3^4=(81), 3^{-4}=(0.0124); 0.25^2=(0.625), 0.25^{-2}=(16).

5. Find $a^{\frac{1}{x}}$

Set hairline directly over **a on LL_3 scale** (or a on **LL/3** scale), move the slide until C:x is also set under the hairline, then set the hairline over C:1, read the value $a^{\frac{1}{x}}$ on LL_3 scale (or $a^{\frac{1}{x}}$ on LL/3 scale) under hairline. Meanwhile, the value $a^{\frac{1}{x}}$ can be read off on LL/3 scale (or a^{-x} on LL_3 scale) under hairline.

Ex: $144^{1/2}$=(12), $144^{-1/2}$=(0.0833).

6. Find logarithm for any base

Ex: find $\lg_9 729$=(3)

Set hairline directly over **9 on LL_3 scale,** move the slide until C:1 is

also set under the hairline, then set the hairline over LL_3:729, the value **3** on C scale under hairline is the answer.

7. Find e^X

Set the hairline directly over any know X on D, then, the value under hairline on **LL_1, LL_2, LL_3, and LL/1, LL/2, LL/3** is the e^X.

8. Find $e^{1/X}$

Set the hairline directly over any know X on **CI,** then, the value under hairline on **LL_1, LL_2, LL_3, and LL/1, LL/2, LL/3** is the $e^{1/X}$.

XIII. Usage of Scales of Hyperbolic Function Sh1, Sh2, and Th

1. Find Shθ

Ex: Sh0.39=(0.4), Set hairline directly over 0.39 on Sh1 scale, read D:0.4 under the hairline is the answer.

Ex: Sh 2.095=(4), Set hairline directly over 2.095 on Sh2 scale, read D:4 under the hairline is the answer.

2. Find Thθ

Ex: Th 0.424=(0.4), Set hairline directly over 0.424 on Th2 scale, read D:0.4 under the hairline is the answer.

3. **Find Chθ**

$Ch\theta = \sqrt{1 + Sh^2\theta}$, read the radian on Sh1, read the Chθ on H under the same hairline. When θ>0.88, the relation Chθ=Shθ/Thθ can be used for calculating the Chθ.

4. Find Cthθ

Cthθ=1/Thθ, Read the radian θ on Th, read the Cthθ on DI under the same hairline.

5.Find sechθ

sechθ=1/chθ, find the chθ first, then calculate sechθ.

6. **Find cschθ**

Cschθ=1/shθ, Read the radian θ on Sh1 or Sh2, read the Cschθ on DI under the same hairline.