AIM MEASURE DISCOVER

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Interactively Master Complex Math

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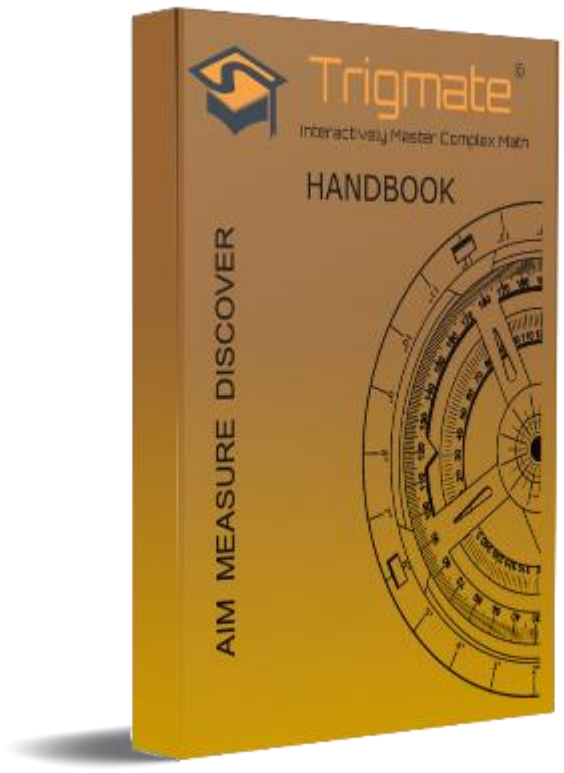

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Trigmate and this guide is dedicated to inspiring teachers all over the world who sacrifice much to help children appreciate and marvel at this wonderful world.

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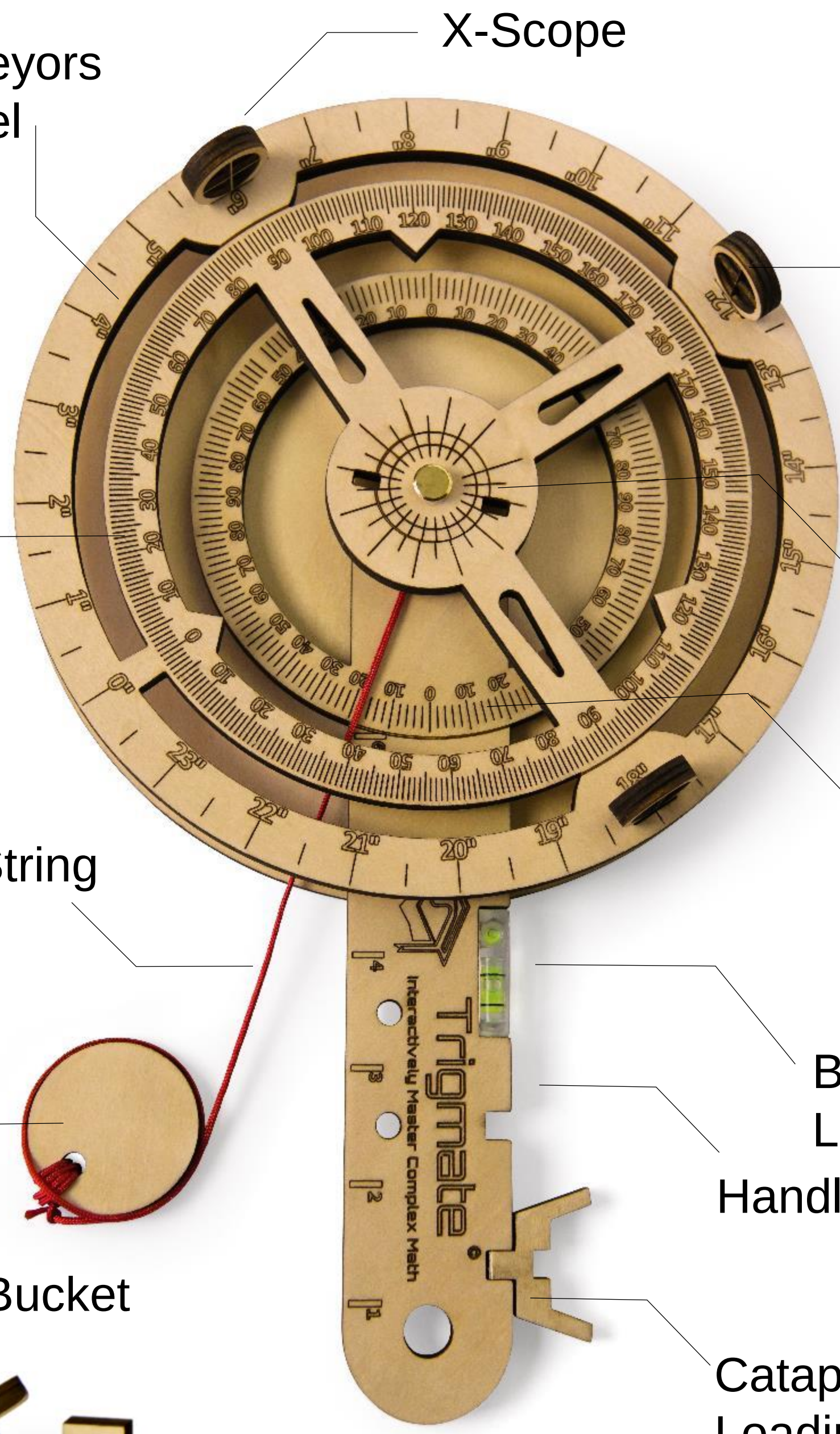
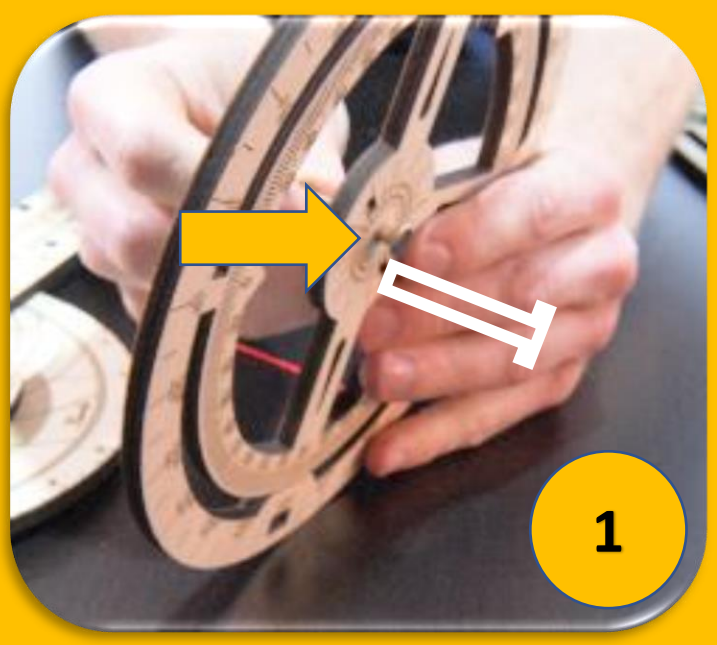

Surveyors Wheel
X-Scope
Outer Degree Dial
Y-Scope
Reflector Slot
Inner Degree Dial
String
Pendulum Weight
Bubble Level
Handle
Catapult Loading
Catapult Bucket
Band stopper

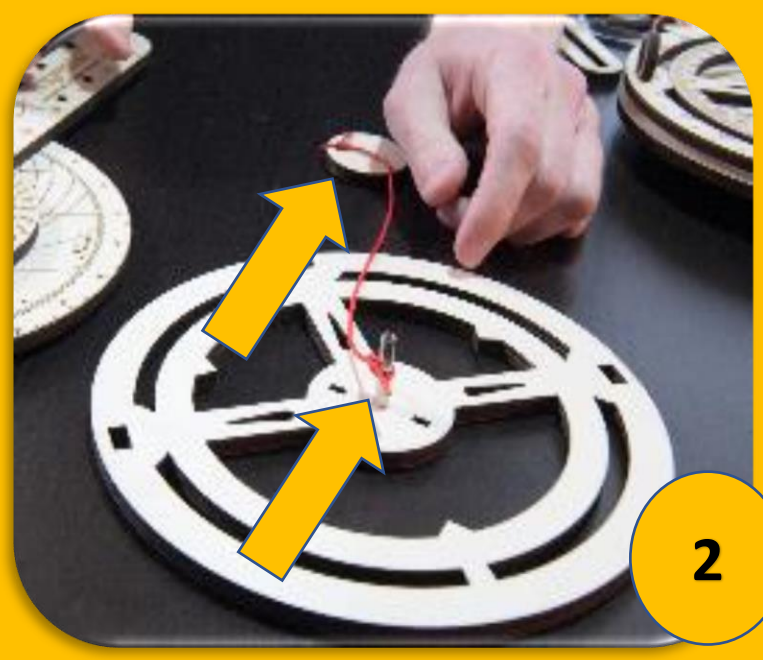
TRIGMATE SETUP

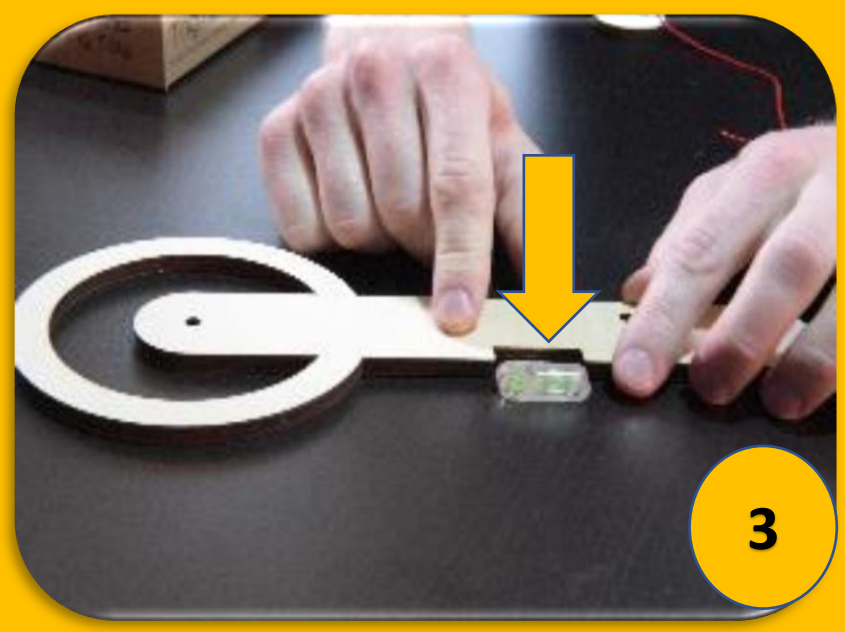
WARNING: Small Parts present choking hazard. Keep away from children under 3yrs and pets.

NOTE : You may need some household/school **Glue** to secure small parts in place if they have loose fit.

1. **Insert screw in main dial as shown.**
2. **Tie small loose knot with string around screw axle and tie other end to disc weights.**
3. **Keep handle face down and peel sticker to attach level. Takes 24 hrs to bond. (Apply glue if needed).**

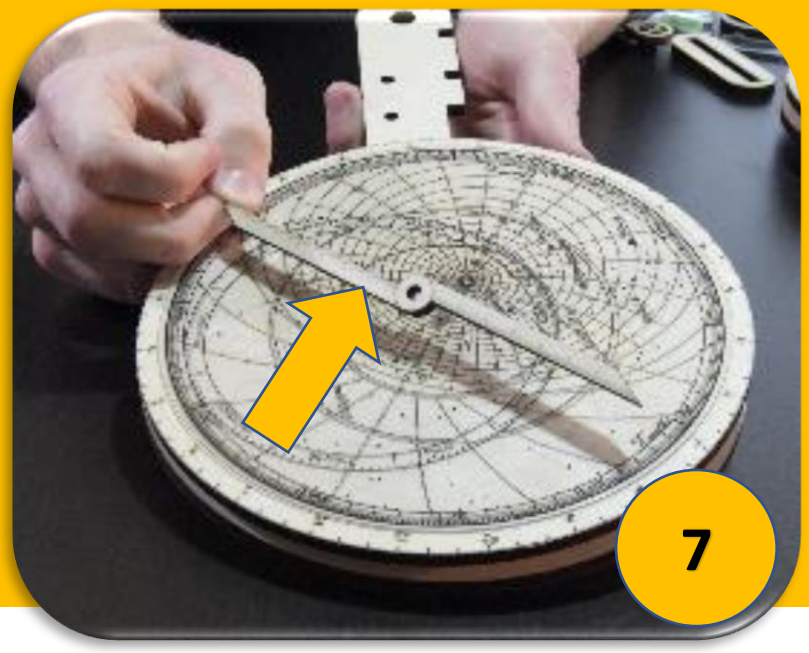


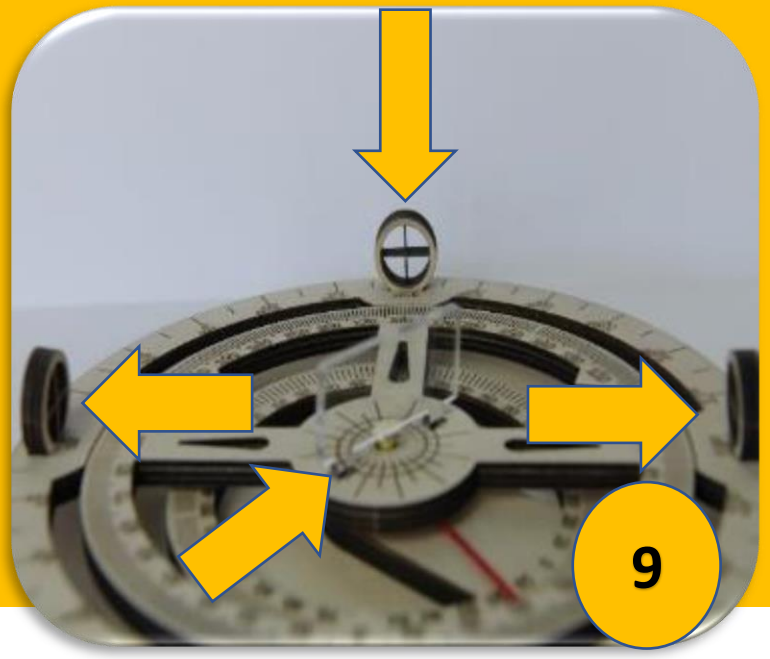




4. **Insert handle through the screw.**
5. **Connect astrolabe plate/Mater.**
6. **Connect star map/Rete.**

7. **Connect rule.**
8. **Tighten screw cap.**
9. **Attach 3 scopes (apply Glue if needed) , *optional : peel film & insert reflector in center***





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Hi I am very excited you are here. I am Ani, I will help you out with Trigmate. Using Trigmate is as easy as these 3 steps

1 AIM

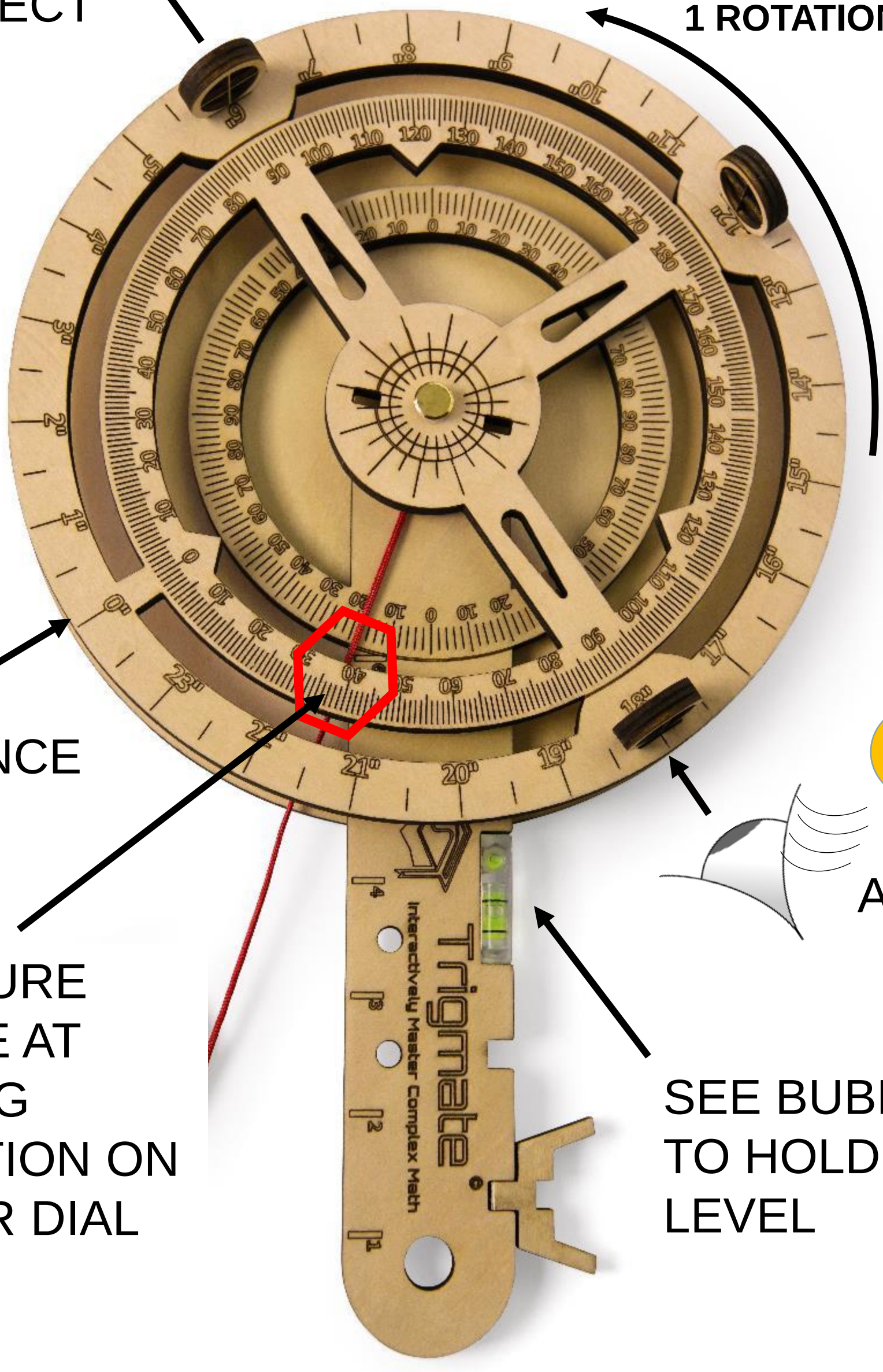
2 MEASURE

3 DISCOVER

Using TRIGMATE is simple

1 AIM AT OBJECT TIP

3 MEASURE DISTANCE BETWEEN
1 ROTATION = 2 FEET



0 DEG REFERENCE

2 MEASURE ANGLE AT STRING LOCATION ON OUTER DIAL

1 AIM

SEE BUBBLE TO HOLD LEVEL

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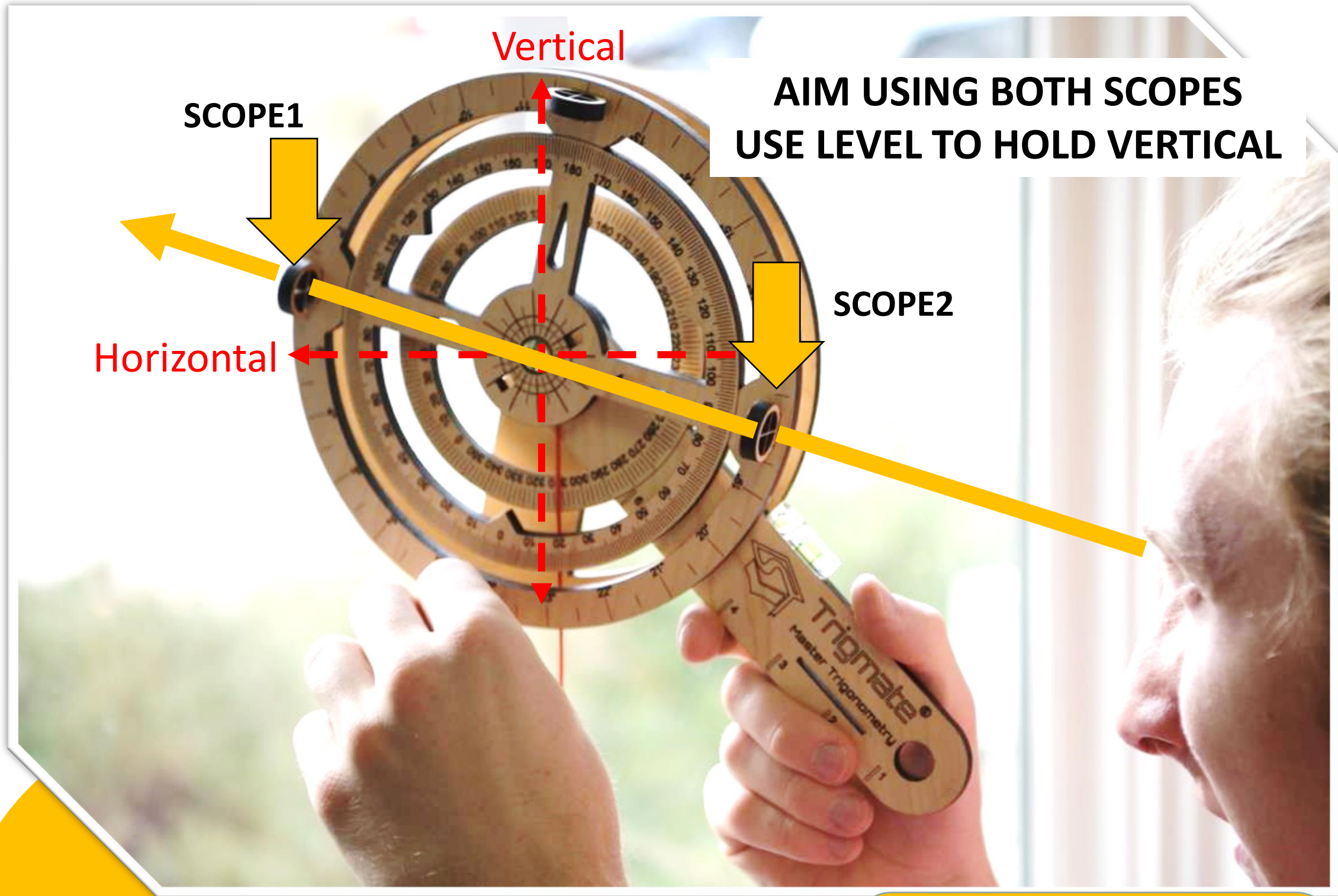
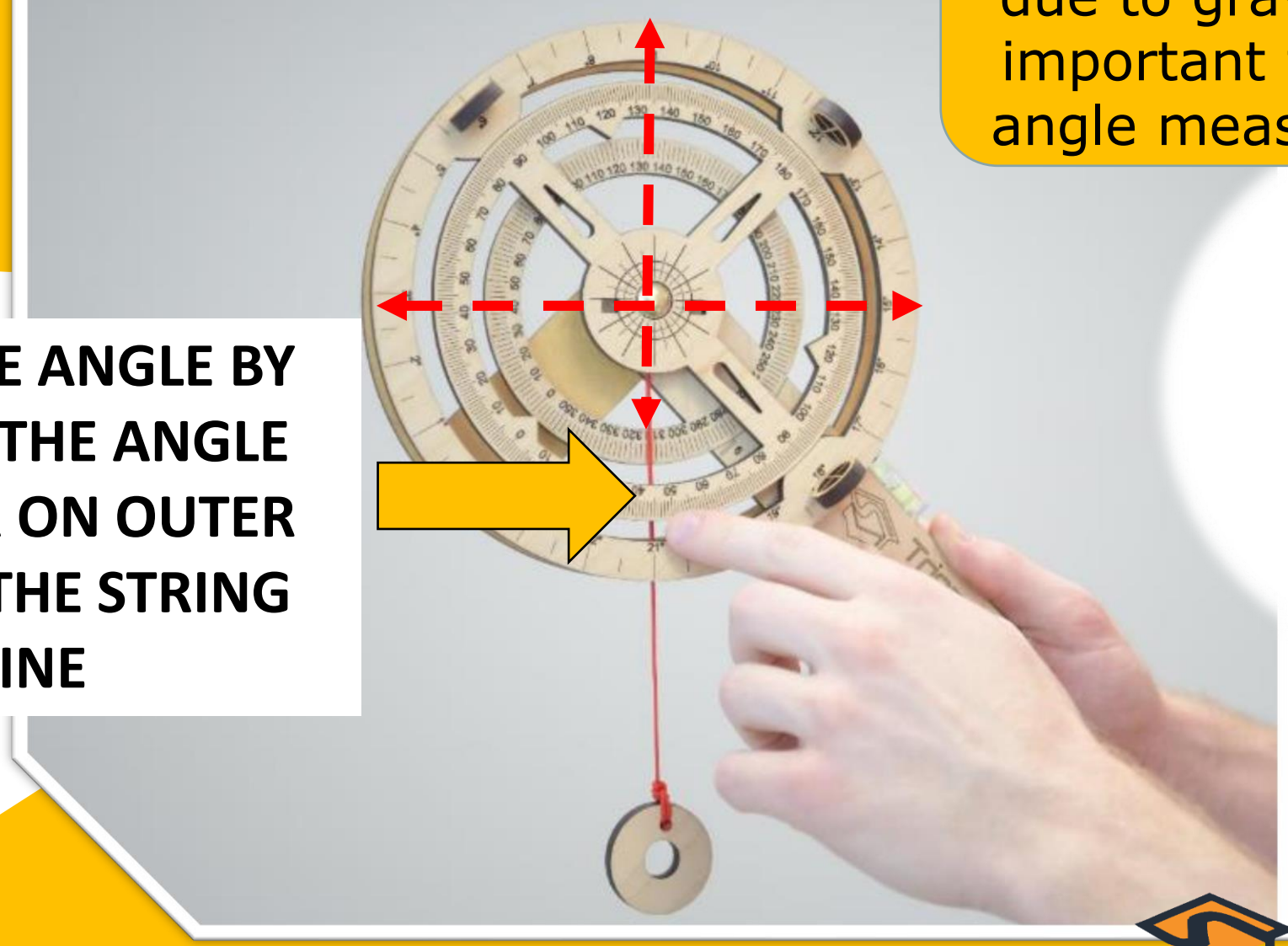
Angle measurement



See how the string is vertical and straight due to gravity, that's important for correct angle measurements!



MEASURE ANGLE BY NOTING THE ANGLE NUMBER ON OUTER DIAL AT THE STRING LINE

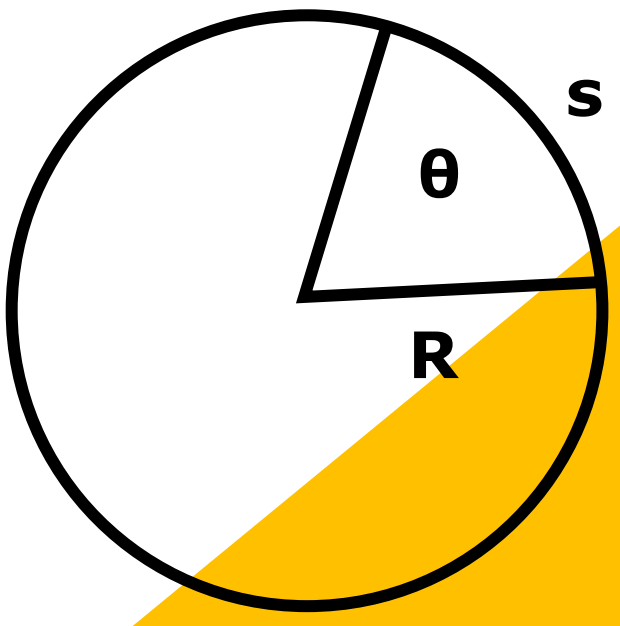
Unit of angle measurement

Angles are commonly measured in degrees, noted by the symbol ^{o} next to the angle value, like for example 45^{o} This is same as saying 45 degrees.

One degree is equal to 1/360 slice of a circle. There are 360^{o} in a circle. A degree may be further divided into 60 minutes, which may further get divided into 60 seconds.

In Geometry, angles in shapes like triangles are noted by symbol **θ "theta"**

Trigmate's outer dial is marked 0 to 180^{o} on each half of the dial making up the same 360^{o} of a circle.

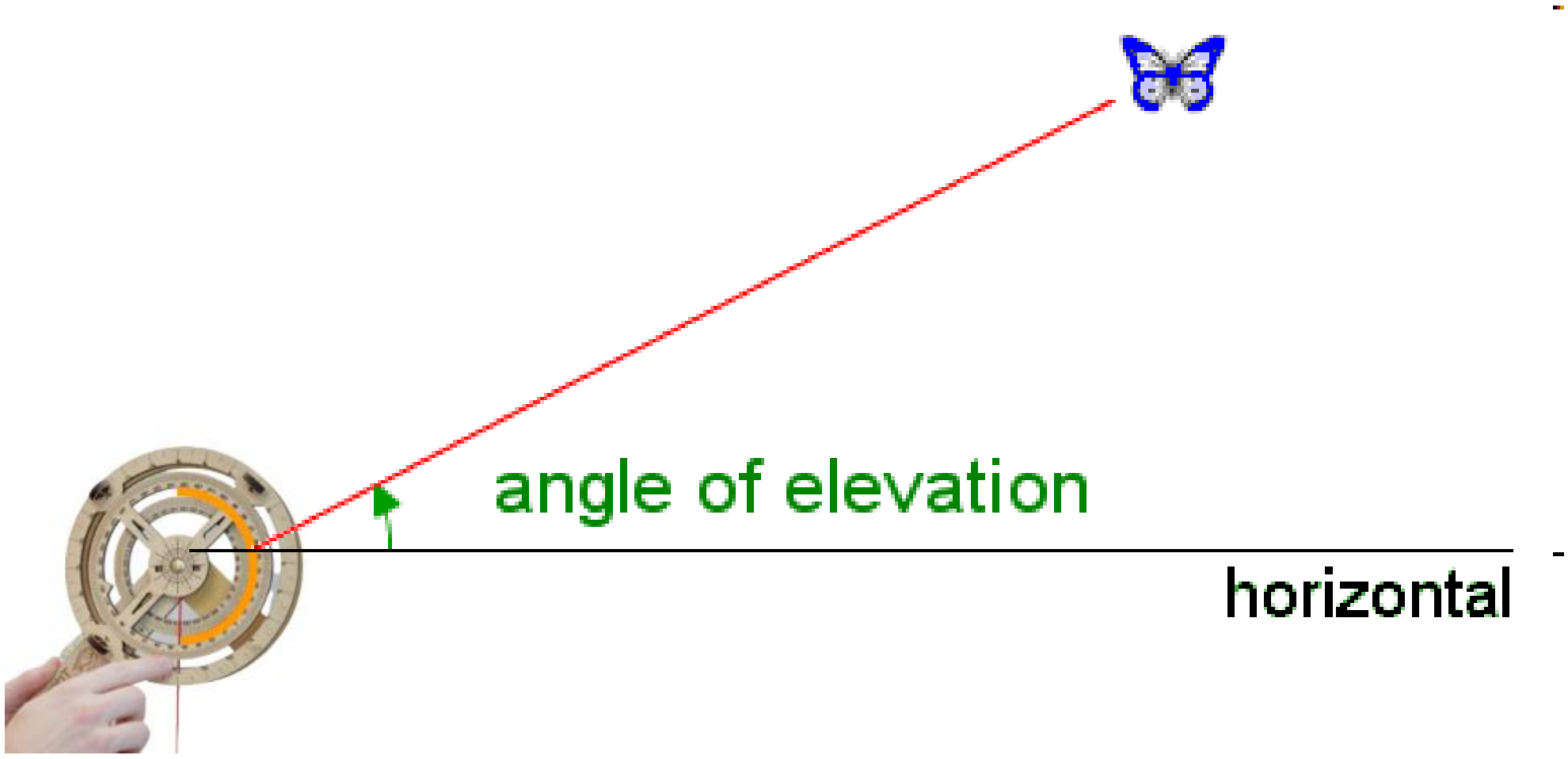


Angles can also be measured in radians.
One radian is equal to the angle of an arc 's" equal in length to the radius of the circle.

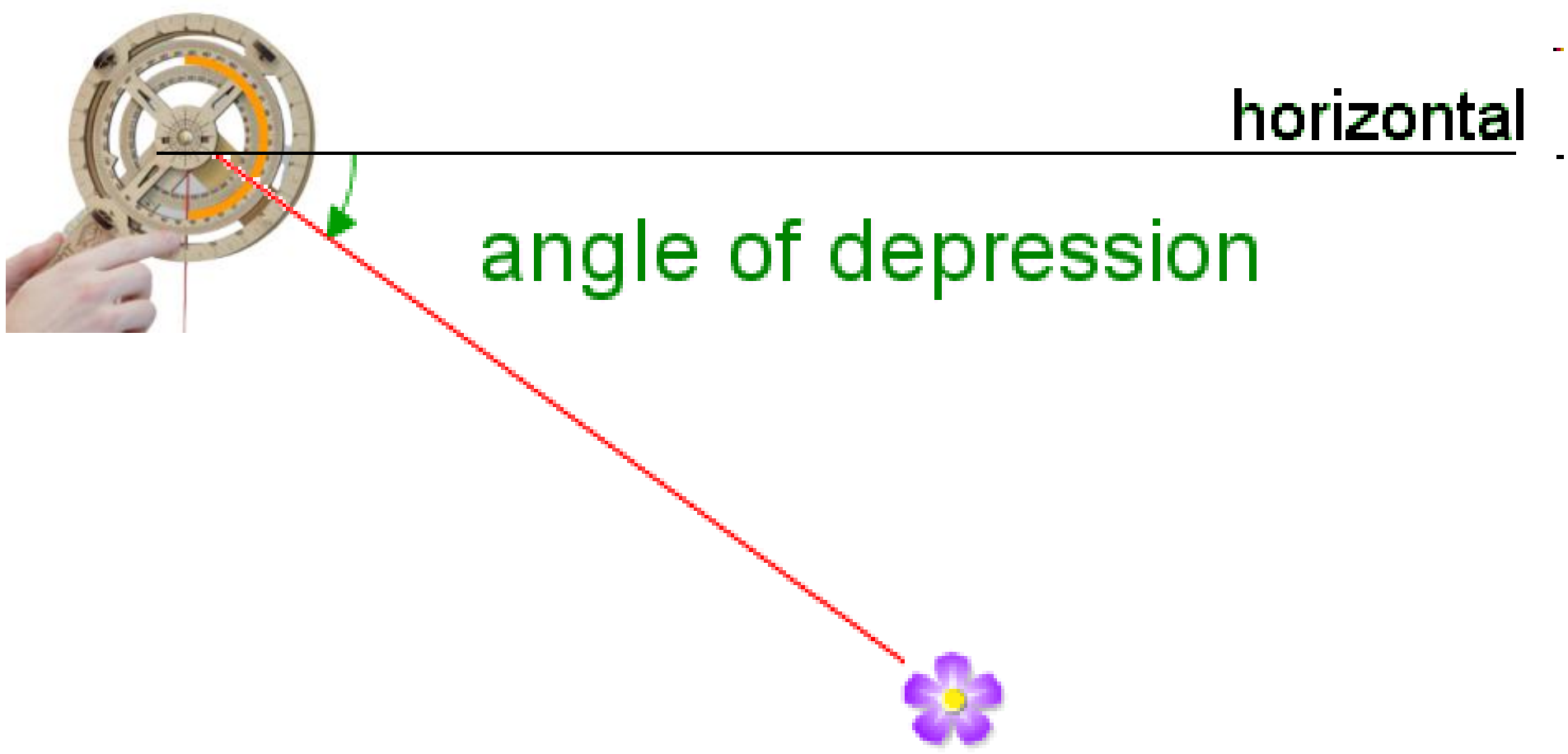
There are **2 π radians** in a circle. So to convert degree to radians, multiply angle in degrees by **π /180**, and reverse it for radians to degrees.

Types of angle measurement

The **angle of elevation** is the angle from the horizontal looking **up** to some object:

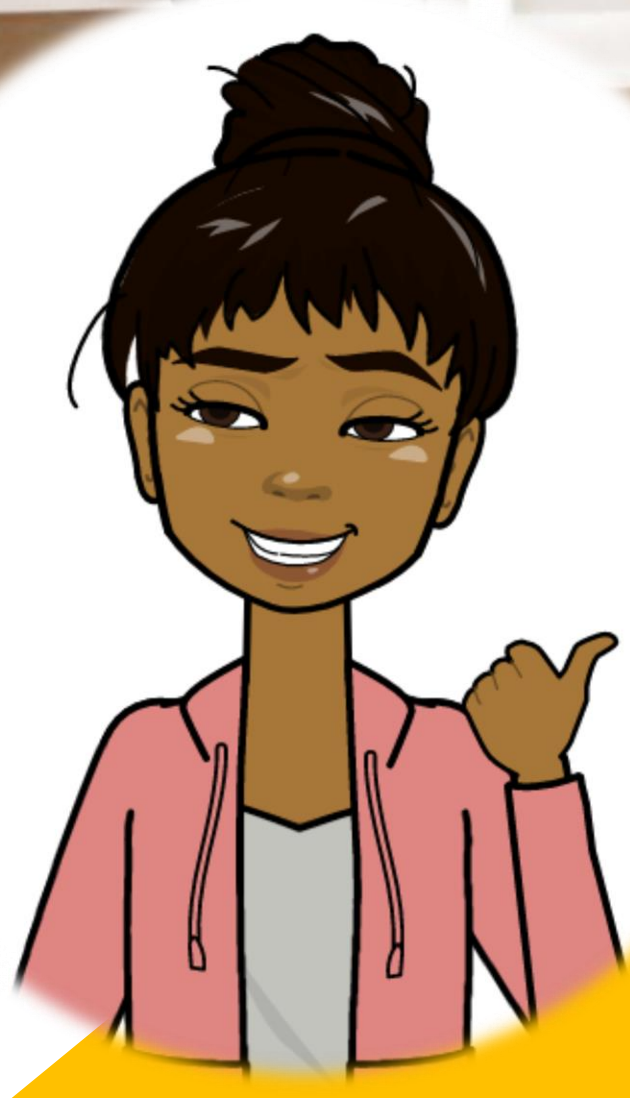


The **angle of depression** is the angle from the horizontal looking **down** to some object:



Applying angle measurement

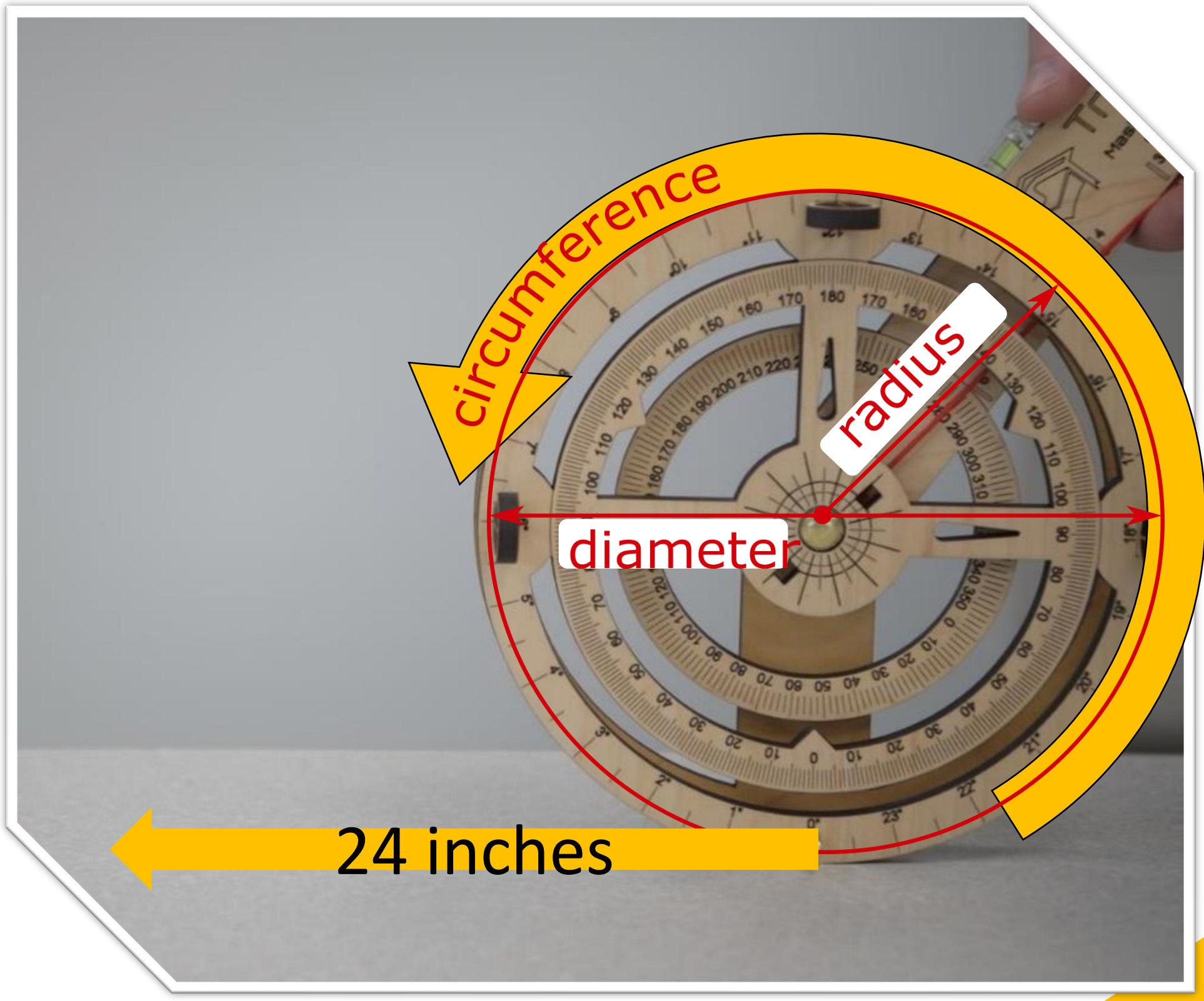
Can you select an object near you and measure the angle of elevation to its top ?



Remember this angle measurement is from your eye level, and not from the ground. Angle measure will be different if its from ground level. can you guess why ?

Well, it forms a different triangle, the angle of elevation will be different

Distance measurement



Pi- pronounced like “pie” is the Greek symbol π

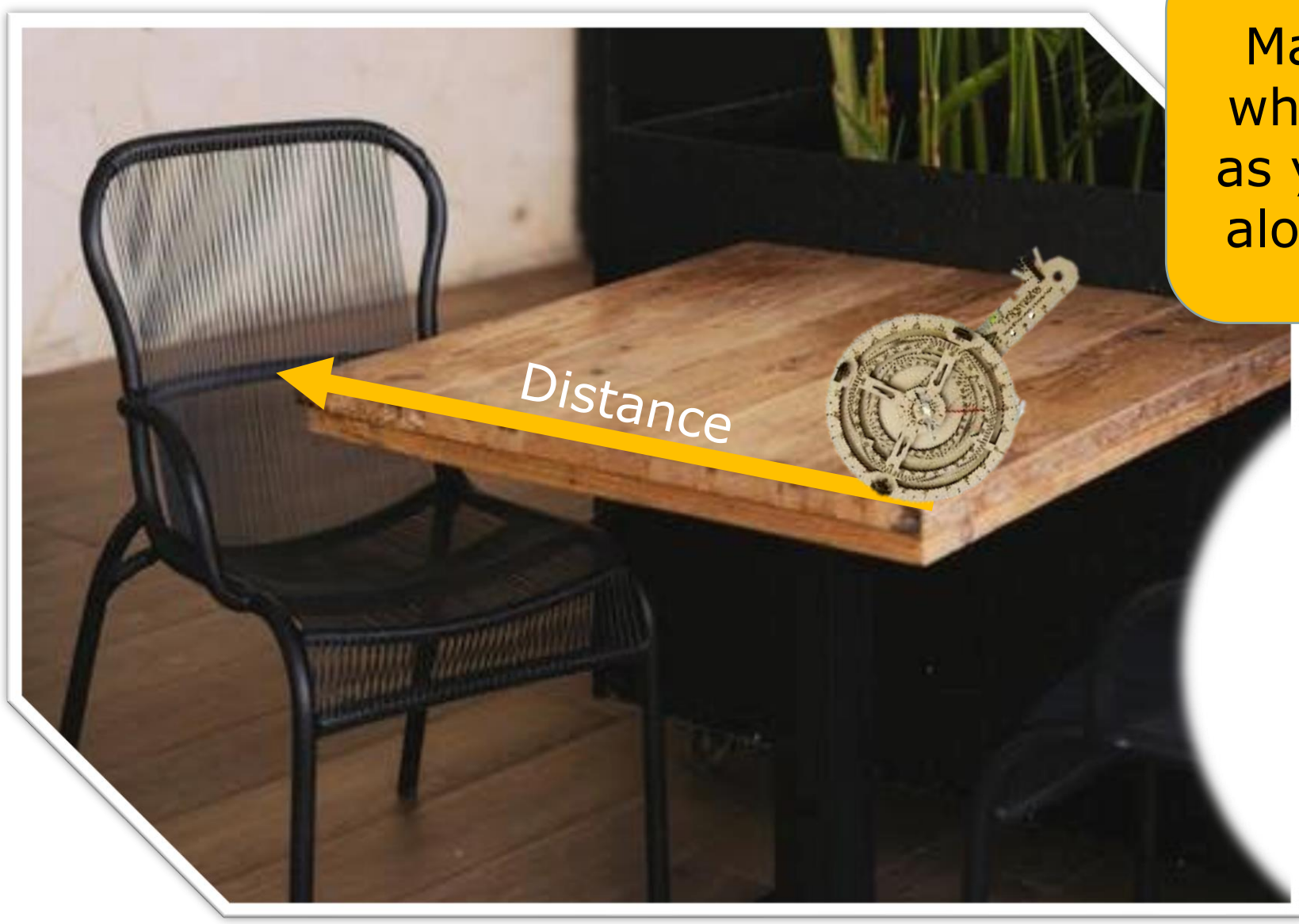
π = Circumference $\div$ by the Diameter of a circle

In Trigmate, **Circumference = 2 Feet or 24 inches.**

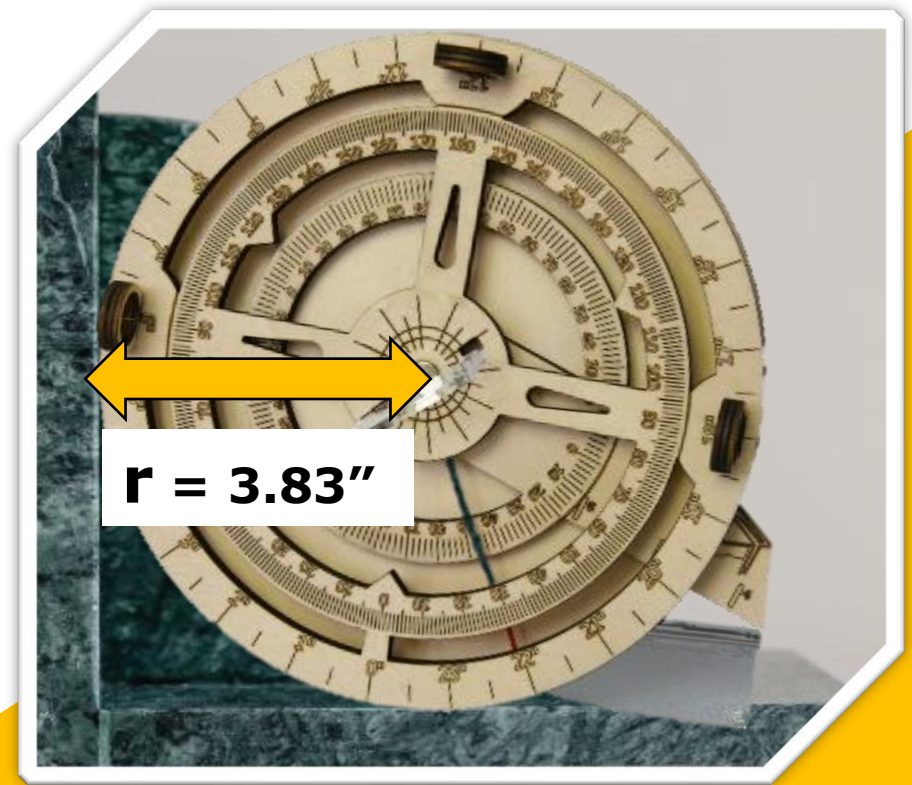
Distance covered in one rotation = 2 Feet.
Roll the wheel and count the turns, this gives you the distance travelled.

(# of rotations) x 2 Feet = Distance travelled

Applying distance measurement



Make sure the outer wheel turns smoothly as you move Trigmate along a straight path!



She is measuring the distance between outdoor objects by rolling it on the ground.

Radius **“r”** of the Dial is 3.83” inches.

Add this to total distance if you are measuring distance up to a wall or upright object.

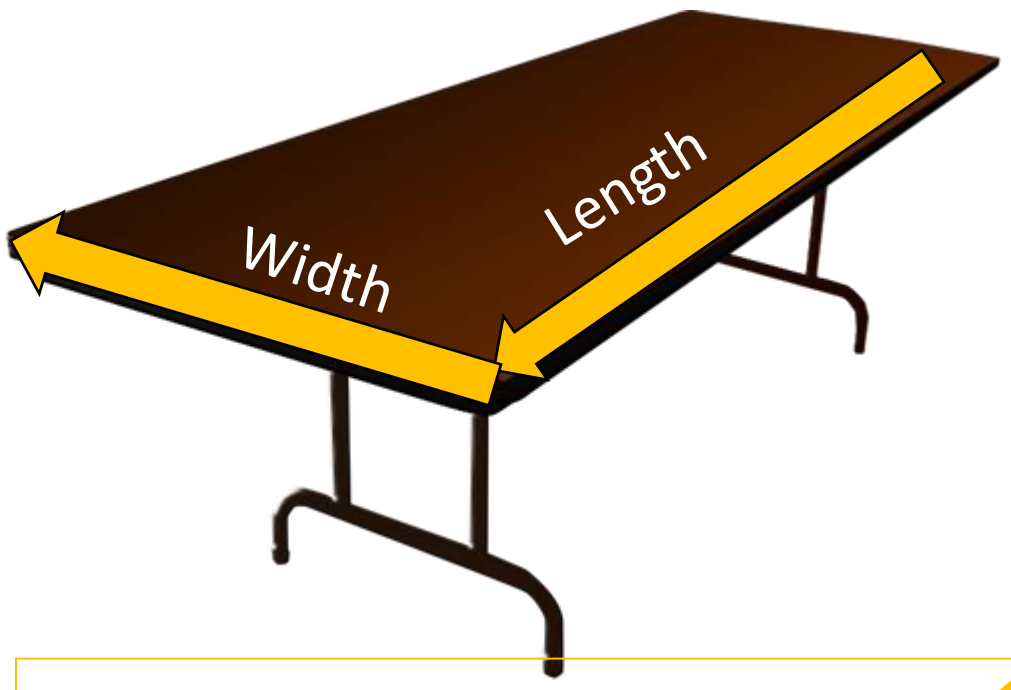
Activity zone 1

Find a table, a dining table works great too!

1. Find “0 inches” on the outer wheel (marked 0”) and place it on the edge of the table.

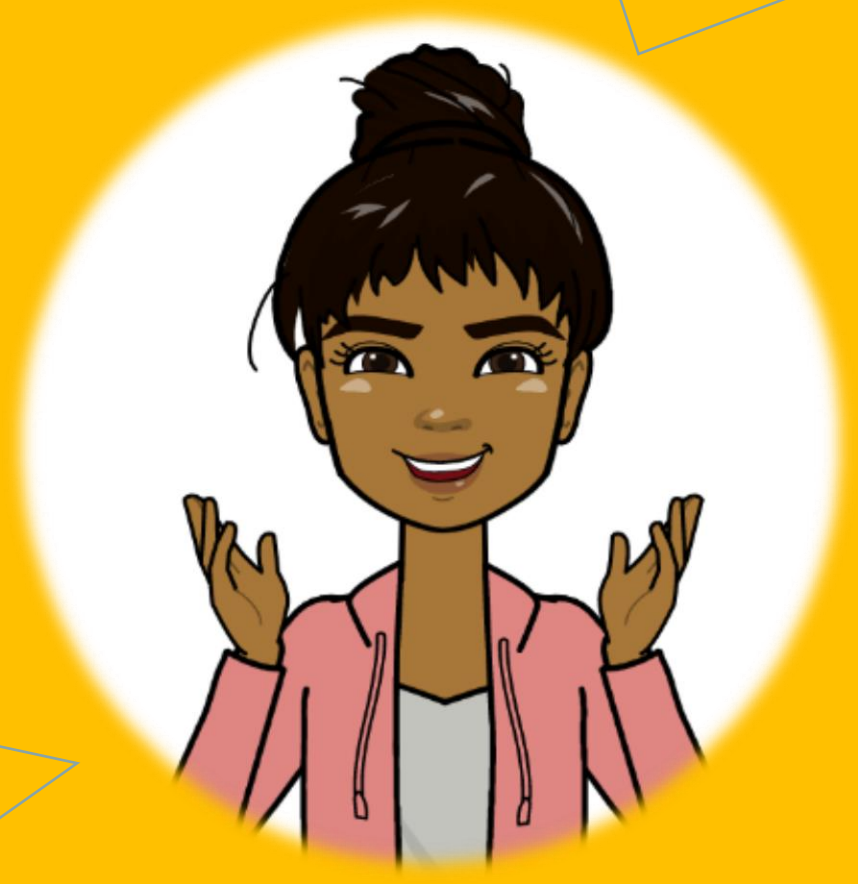
2. While holding the handle, roll Trigmate from one edge of a table to the opposite edge along a straight path. Stop at the opposite edge end.

3. How many turns did you count ?



Area = Length x Width

Area is measuring space covered in all directions. Can you find the flat area of the same table ?



Good, now can you find a flat surface or area you can measure in your surroundings using Trigmate ?

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Activity zone 2

Remember “Elevation” angle is looking up and “Depression” is looking down!

Lets experiment with what we just learned.

Can you find the angle of elevation of something tall or high inside your house or in your classroom using Trigmate ?

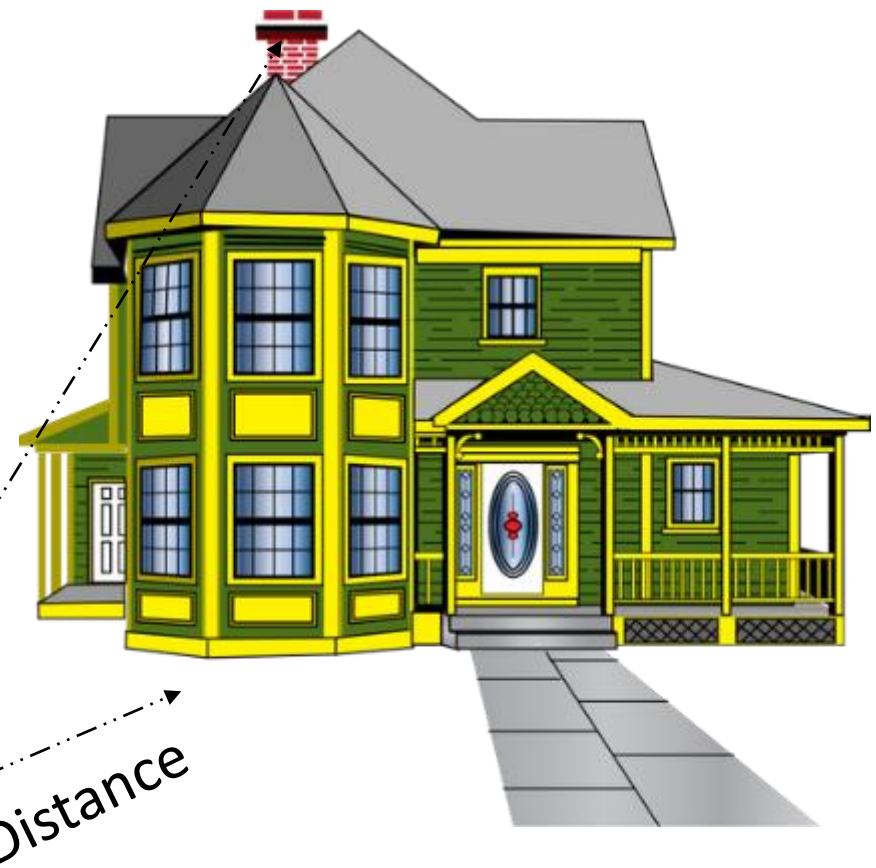
How about the top of the door or a ceiling light ?

Lets make it more fun ! How about taking it outdoors. With your teacher or parent’s help find a tall vertical object to aim and measure the angle and distance between you and the object.

ALWAYS PRACTICE SAFETY FIRST

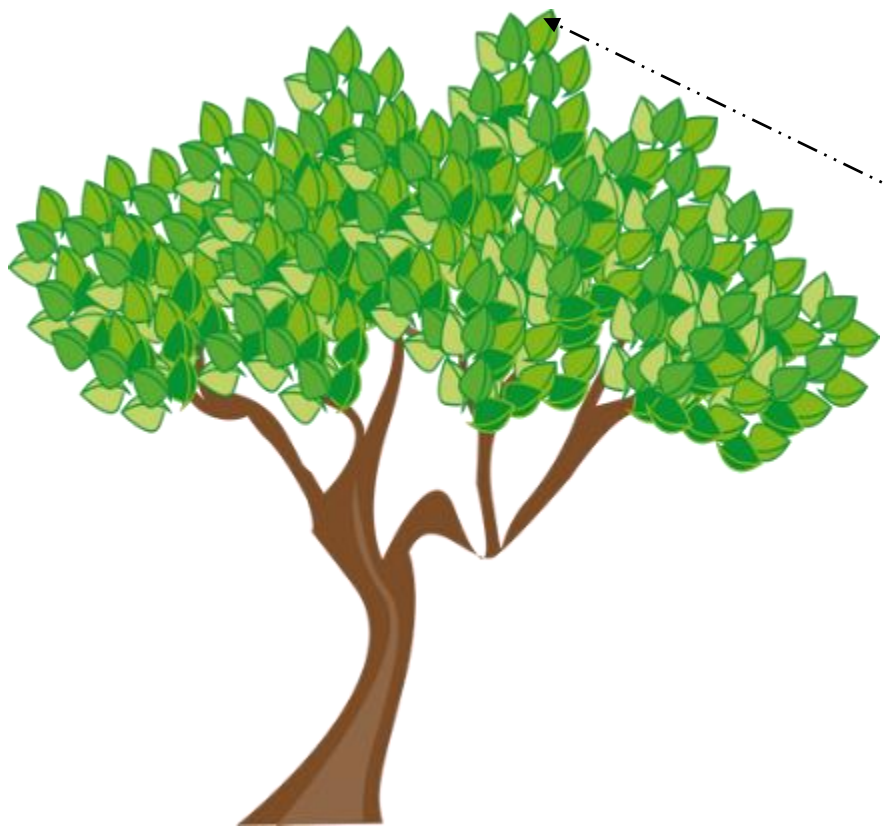
Activity zone 3

With your teacher or parent's help can you measure the angle of elevation of a building?



How about measuring the angle of elevation of a tree or even a moving airplane?

What was the angle? Did all of you get the same result ?



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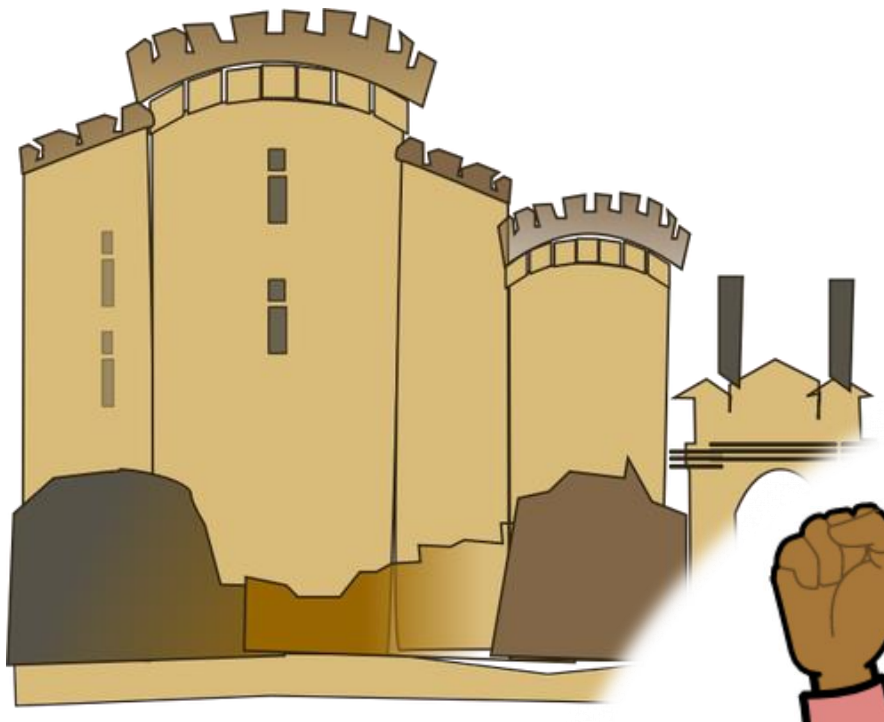
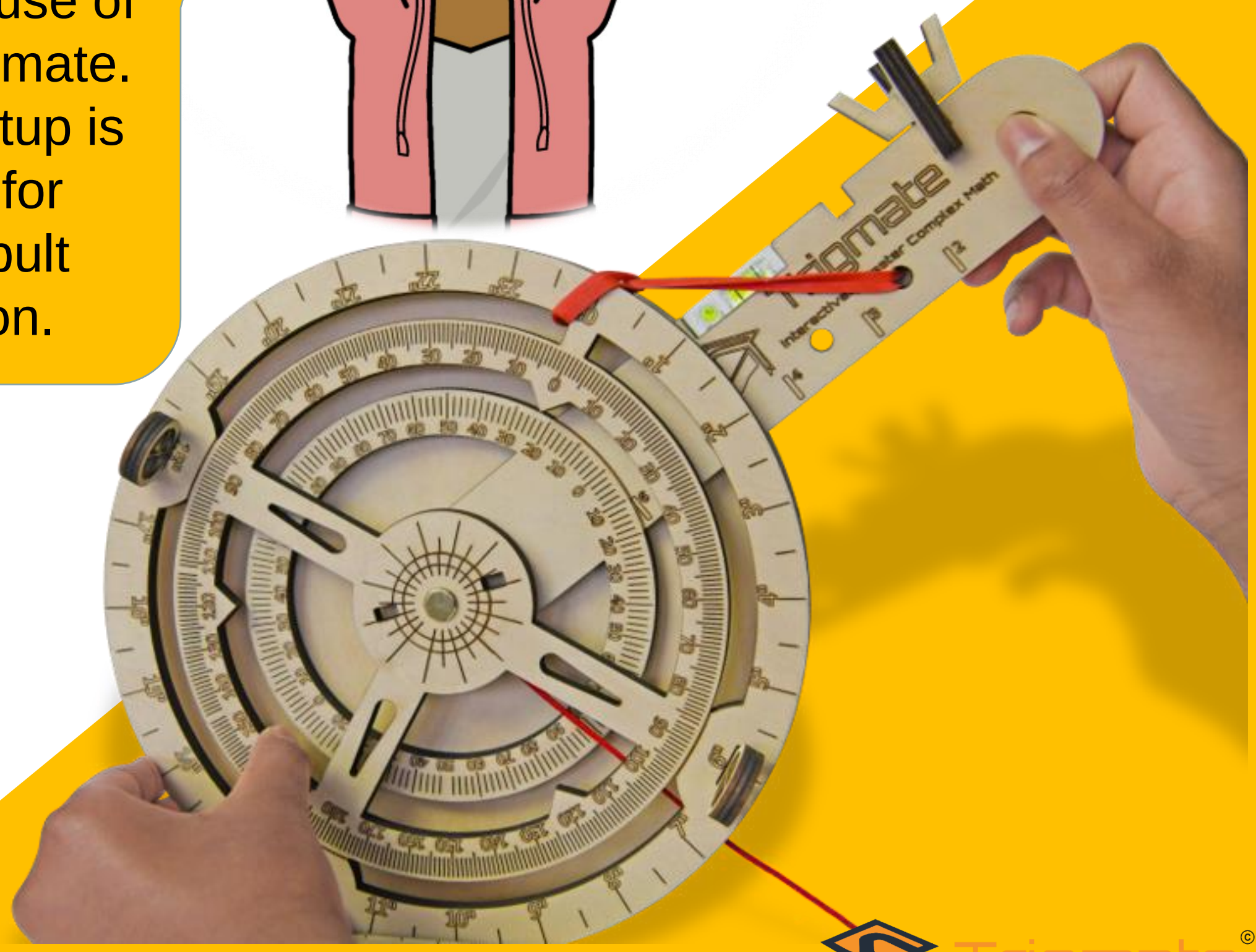
TRIGMATE AS A CATAPULT



My Favorite thing about Trigmate….

CATAPULT BATTLE!!!

Remember, catapult setup prevents normal use of the Trigmate. This setup is only for catapult action.



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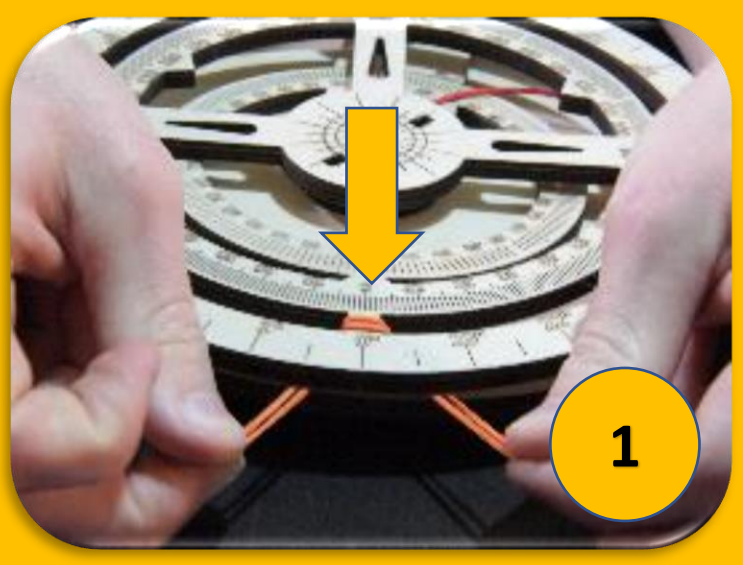
CATAPULT SETUP

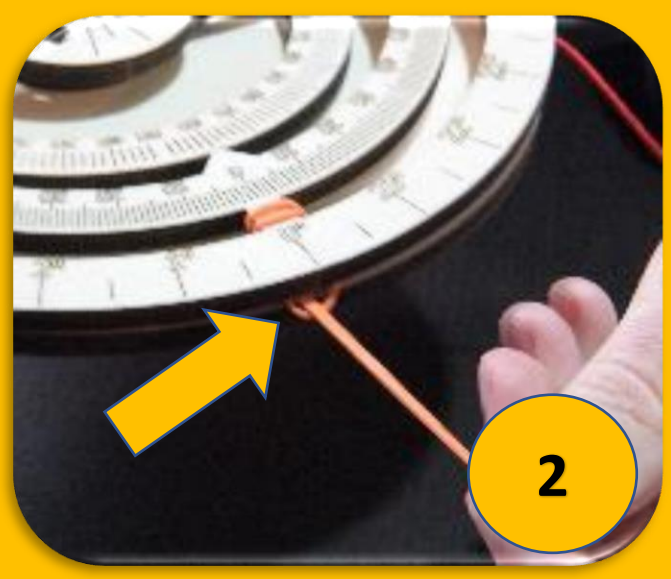
WARNING: Small Parts present choking hazard. Keep away from children under 3 yrs and pets. Do Not aim or launch object at each other.

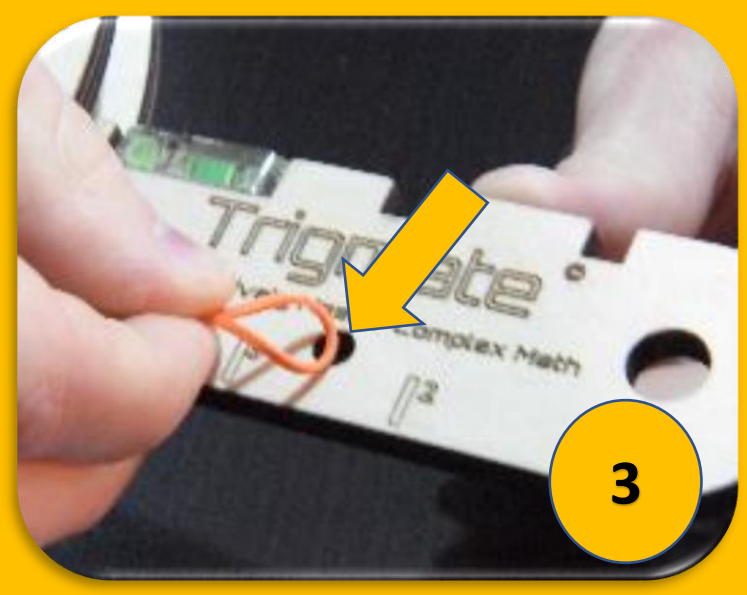
Complete Trigmate setup before this.

This setup restricts normal use of Trigmate

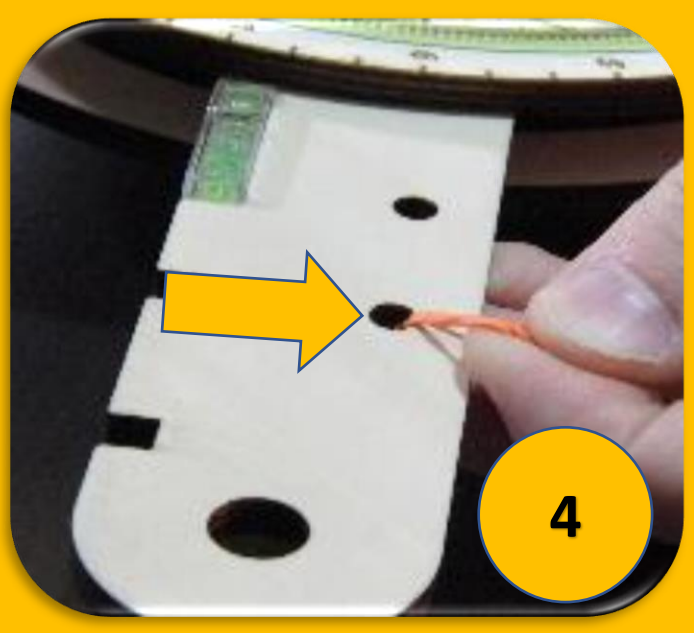
1. **Loop rubber band at 0 deg.**
2. **Complete loop at 0 deg.**
3. **Insert other end of the band into the hole (3 holes = 3 settings) .**



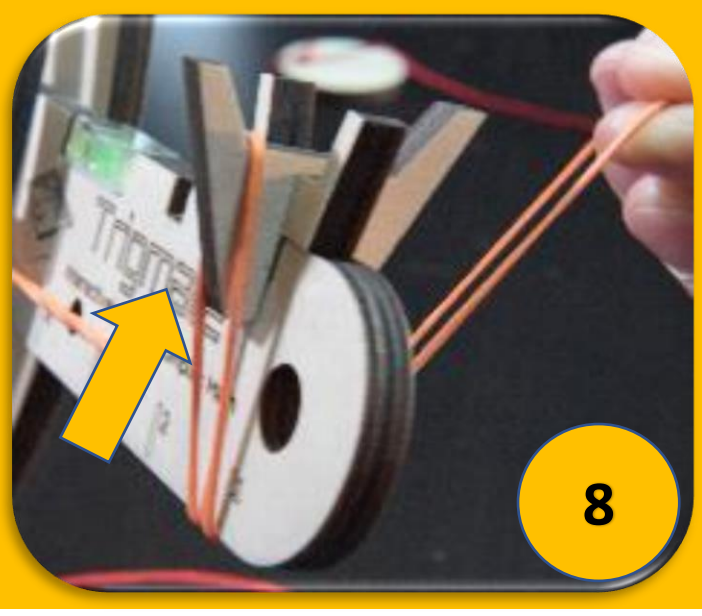


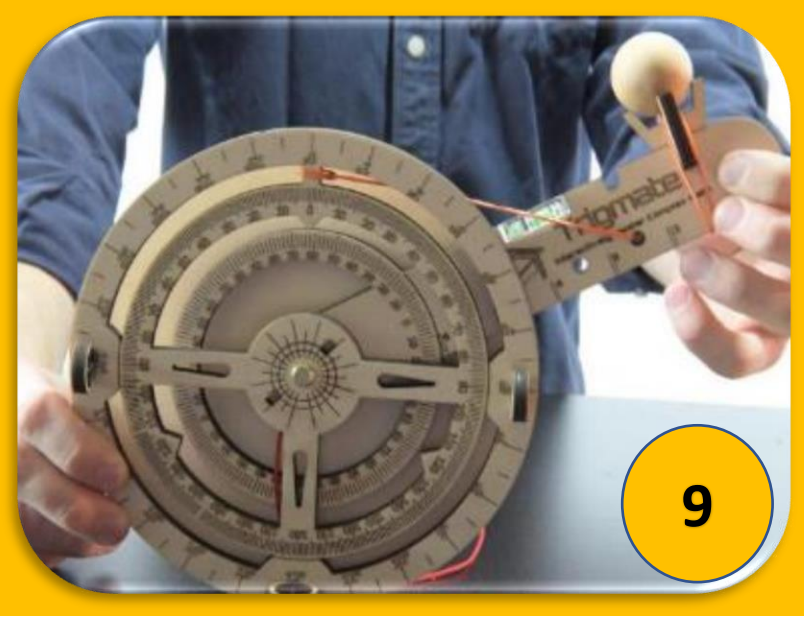


4. **Bring band through hole.**
5. **Insert band ‘H’older. (Optional: Use two bands to increase firing strength)**
6. **Attach bucket base part. Gently attach part, excessive force can break the part.**

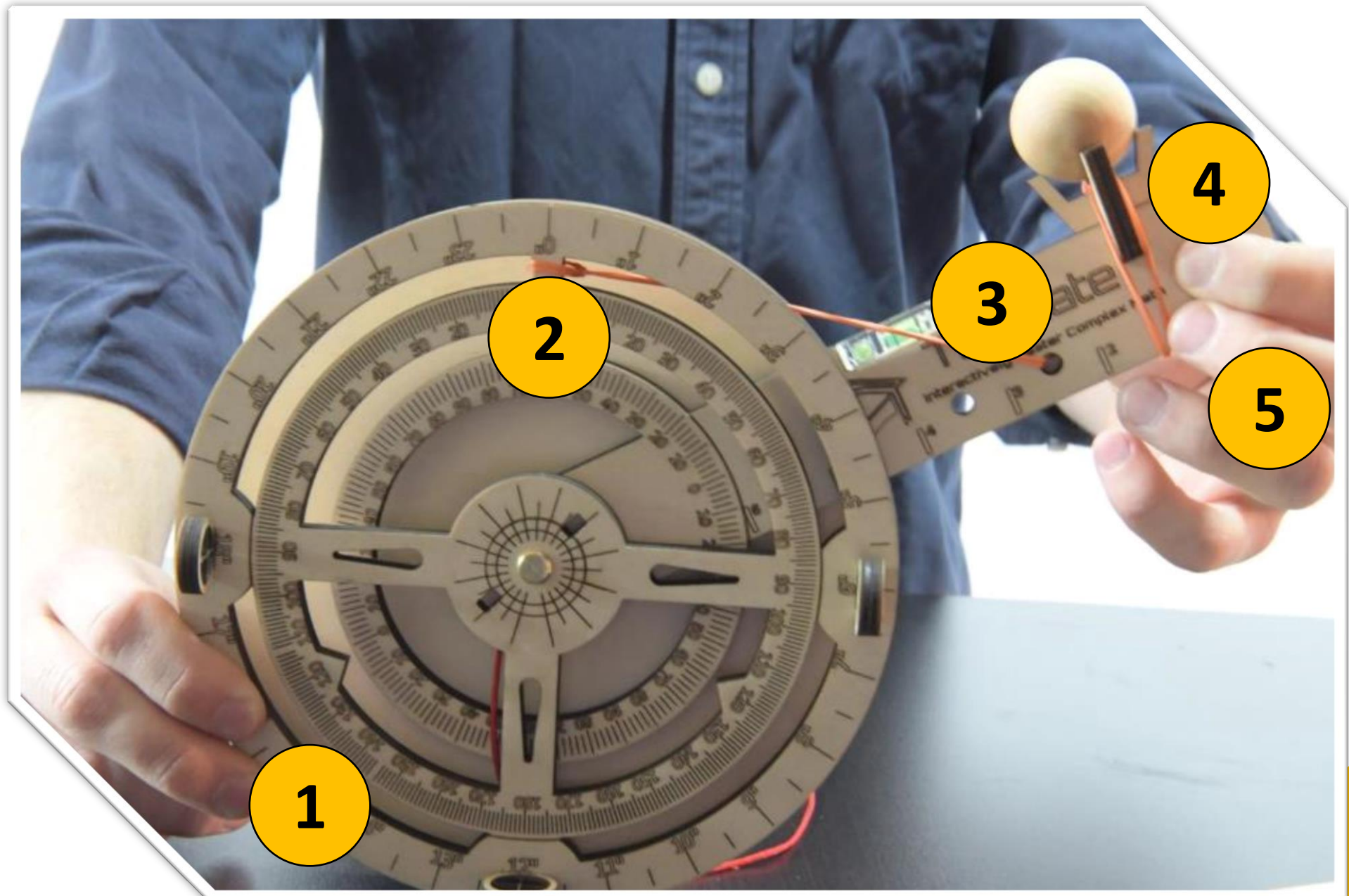


7. **Attach bucket top part. Gently attach part, excessive force can break the part.**
8. **Optional: Loop extra band around top part if parts are loose.**
9. **Hold outer dial and pull handle to LAUNCH !**





Catapult launch checklist



1. **Hold outer wheel firmly to the ground. Do not let the dial slip or turn as you pull the handle lever.**

2. **Ensure the rubber band anchor point is on top at zero.**

3. **Ensure the rubber band is held on the handle lever using the “H” stopper.**

4. **Ensure the payload bucket is secured using the second band around the handle.**

5. **Test the handle lever by pulling it back and releasing**

USE 2 Rubber BANDS for steps 2 & 3 for more **FIRE POWER**!

ALWAYS PRACTICE SAFETY FIRST

Catapult Battle

Build Paper cup towers and make aluminum foil balls to start your battles, take turns, protect your towers, launch at theirs…All out invasion!!!

A smart competitor monitors:

- **Pull angle of the handle on the outer dial**
- **Distance to target**
- **Ball-size and weight**

And Repeat-ability to control their destiny !

Introduction to Trigonometry

Trigonometry means measurements with triangles. It is a field of math involving lengths, heights and angles of different triangles.

It was first developed in connection with astronomy, with applications to navigation and construction of calendars. This was around 2000 years ago.

Geometry is much older, and trigonometry is built upon geometry. The origins of trigonometry can be traced to the civilizations of ancient Egypt, Mesopotamia and India more than 4000 years ago.

Even the name “Trigmate” means being an aid to you for learning Trigonometry!

Leveraging Trigonometry

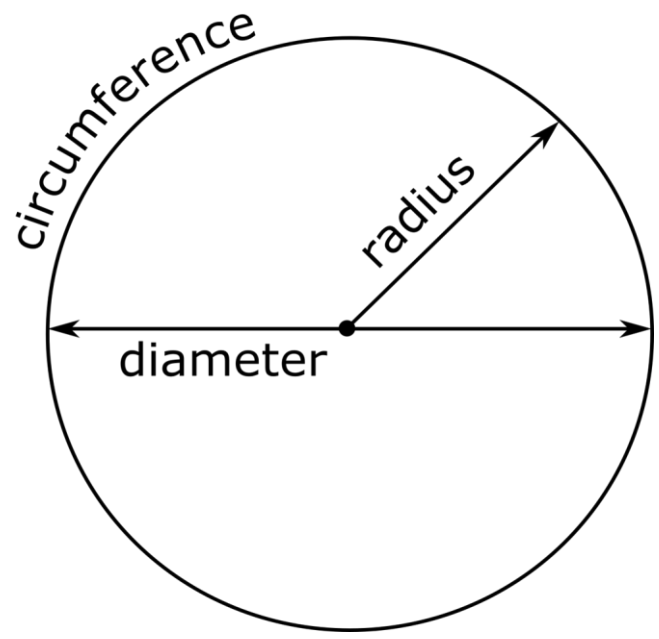
First important step in applying math and trigonometry is knowing what the different letters represent.

- a, b, c are measures of sides;
- x, y are coordinates on a graph;
- m = slope often measured as θ;
- h = height;

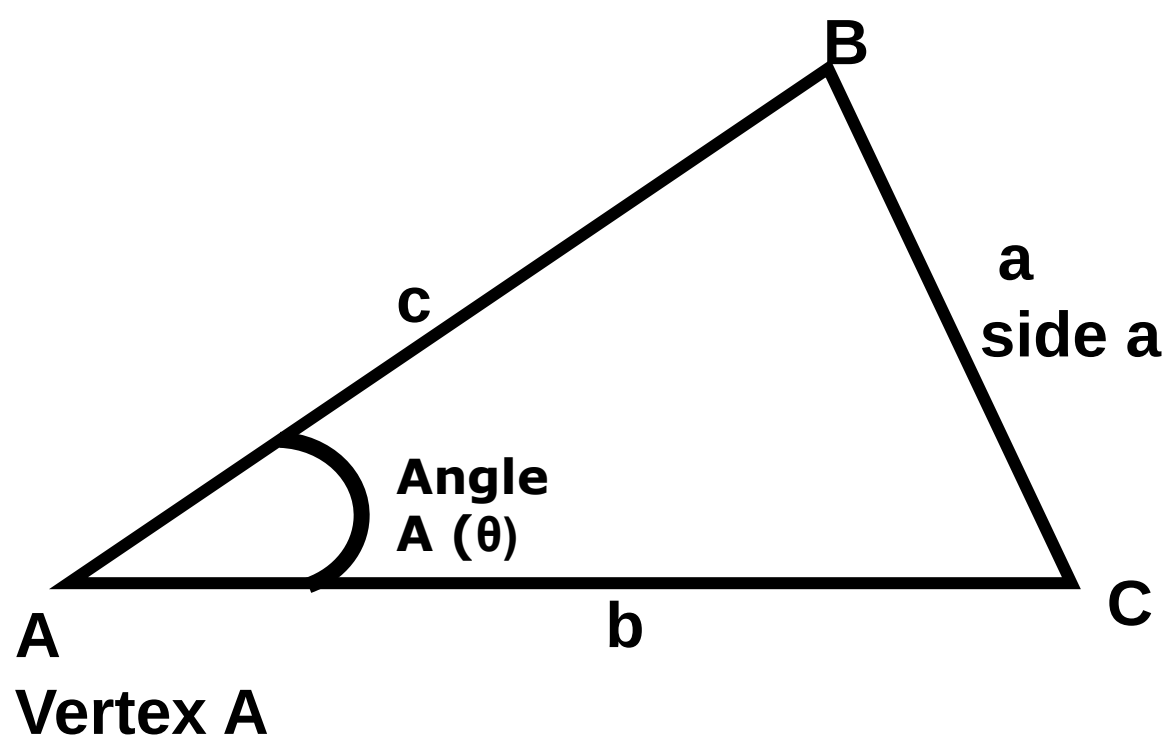
Greek letter θ “theta” is used to note angle measures in triangles.

<u>In circles</u>

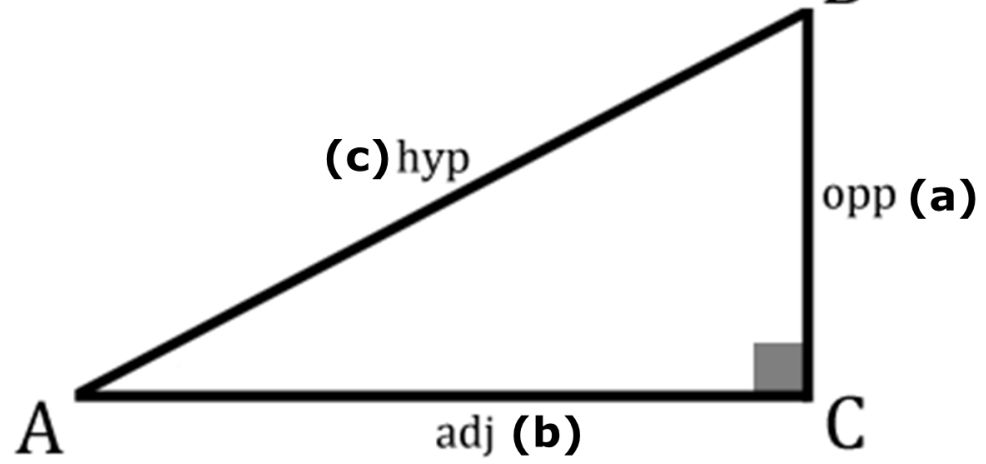
- r = radius;
- d = diameter or distance;



<u>Right Angled Triangle</u>

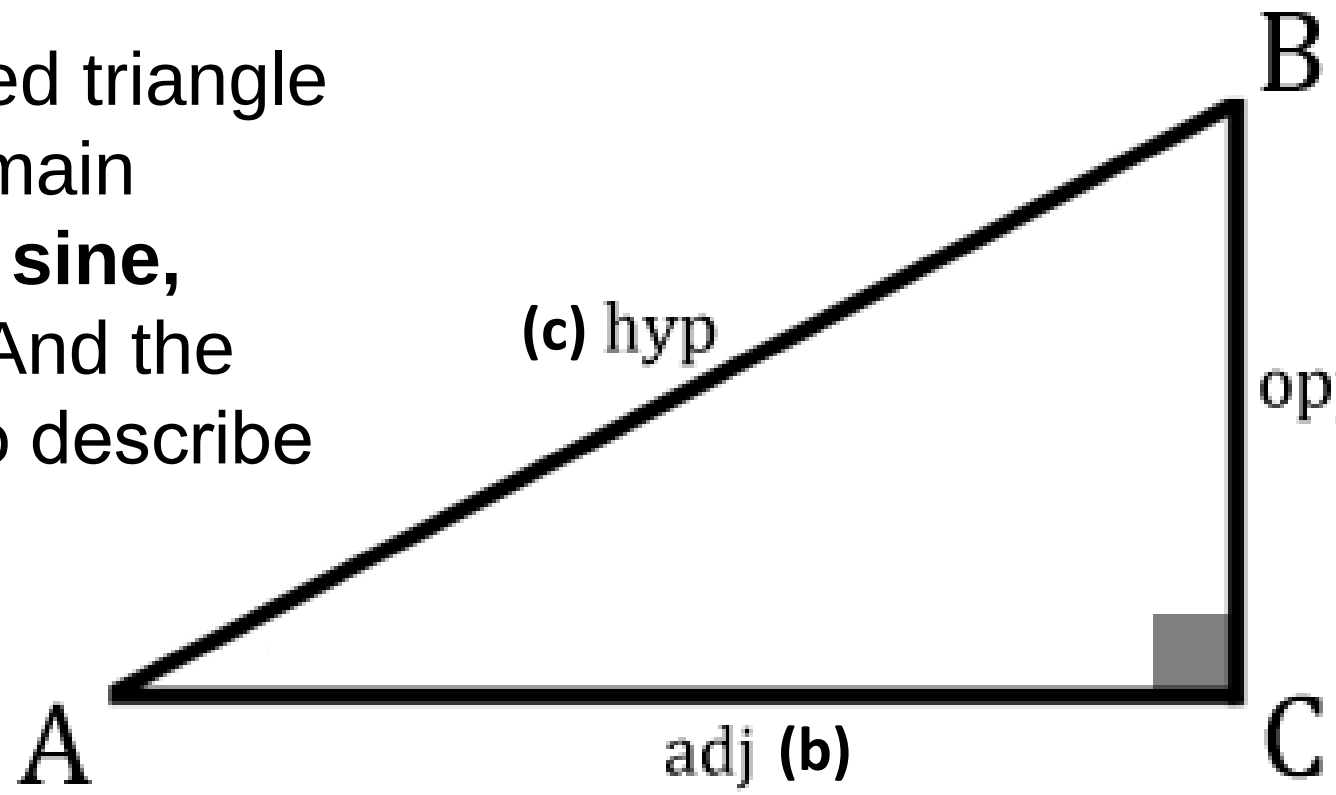


- We will focus on angle 'A’
- The opposite side of the triangle is the side furthest from the angle ‘A’
- Adjacent side is next to the angle
- Hypotenuse of a triangle is always the side opposite to the right angle.



Trigonometric ratios

Leveraging a right angled triangle shape, there are three main trigonometric functions: **sine, cosine, and tangent.** And the Greek letter θ is used to describe the focus angle.



$$Sin\,\theta = \frac{Opposite}{Hypotenuse} = \frac{a}{c}$$

$$Cos\,\theta = \frac{Adjacent}{Hypotenuse} = \frac{b}{c}$$

$$Tan\,\theta = \frac{Opposite}{Adjacent} = \frac{a}{b}$$

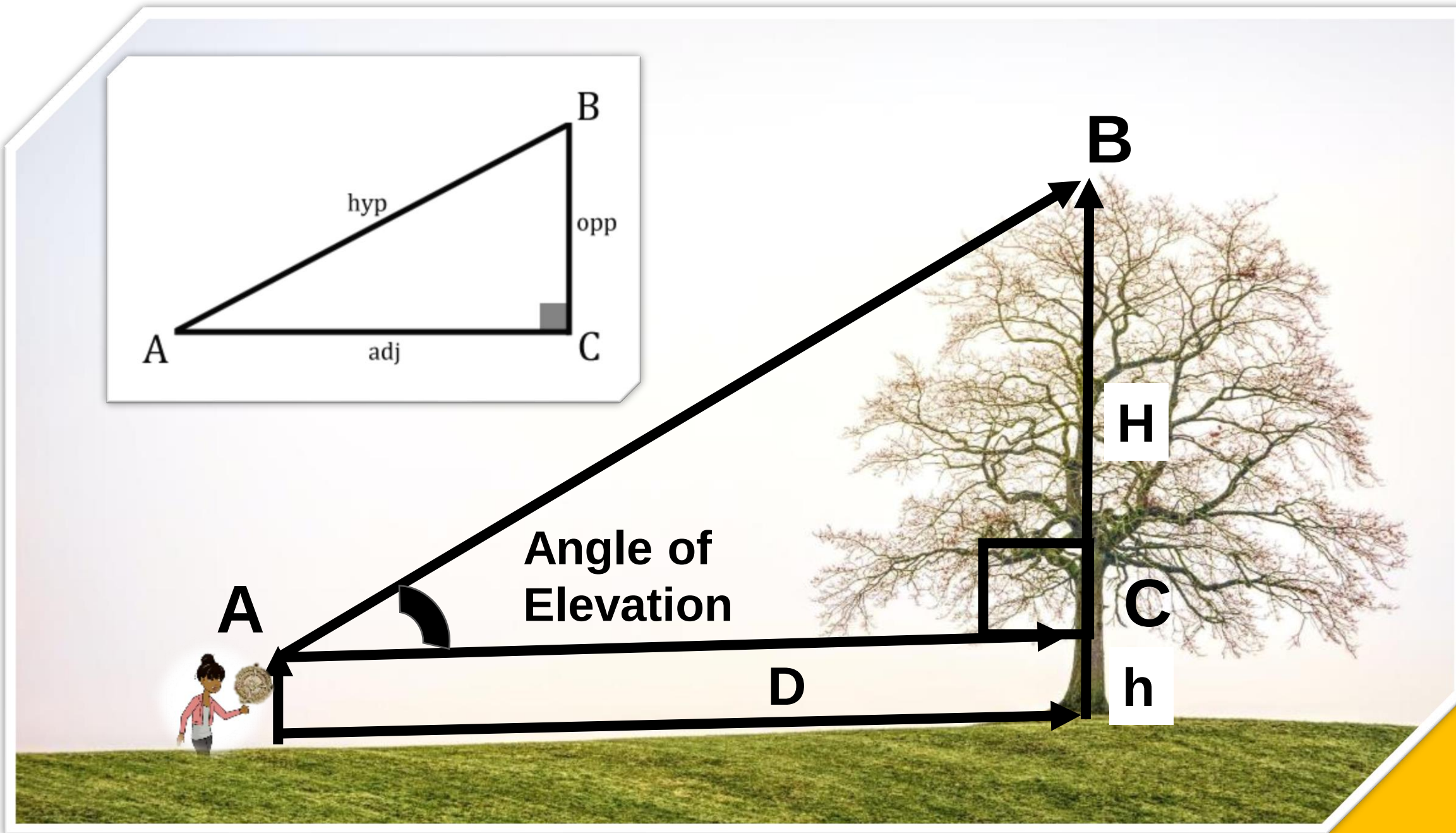
Here's a trick to remember it sing it like a jingle

"SOH CAH TOA"

"SOH CAH TOA"

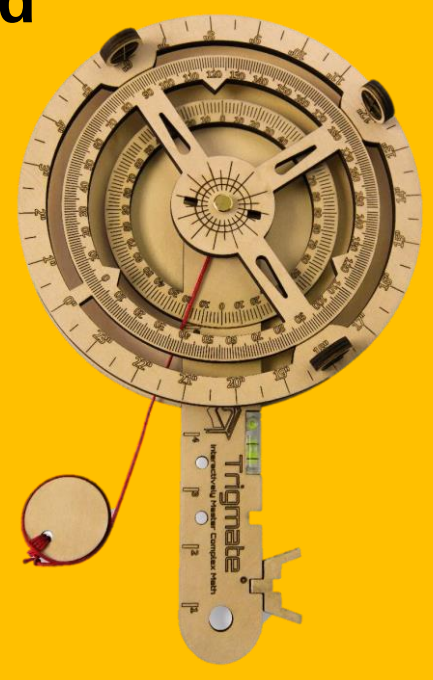
$$sin\,\theta = \frac{O}{H} \quad cos\,\theta = \frac{A}{H} \quad tan\,\theta = \frac{O}{A}$$

Height Measurement



$$\mathbf{T}an\,\theta = \frac{Opposite}{Adjacent} = \frac{a}{b}$$

1. Aim to the top of the Tree.
2. Record the Angle of Elevation.
3. Now record the Distance between you and the tree. And remember to record the number of revolution of the outer wheel. 1Rotation = 2 Feet or 24 inches
4. Using the Trigonometry Table (next page), find the Tan value of the angle.



Now H = Tangent (Angle) x Distance

Total Height from ground will be H + h, where ‘h’ is the height you are holding Trigmate at, which approximately is your height +/- few inches

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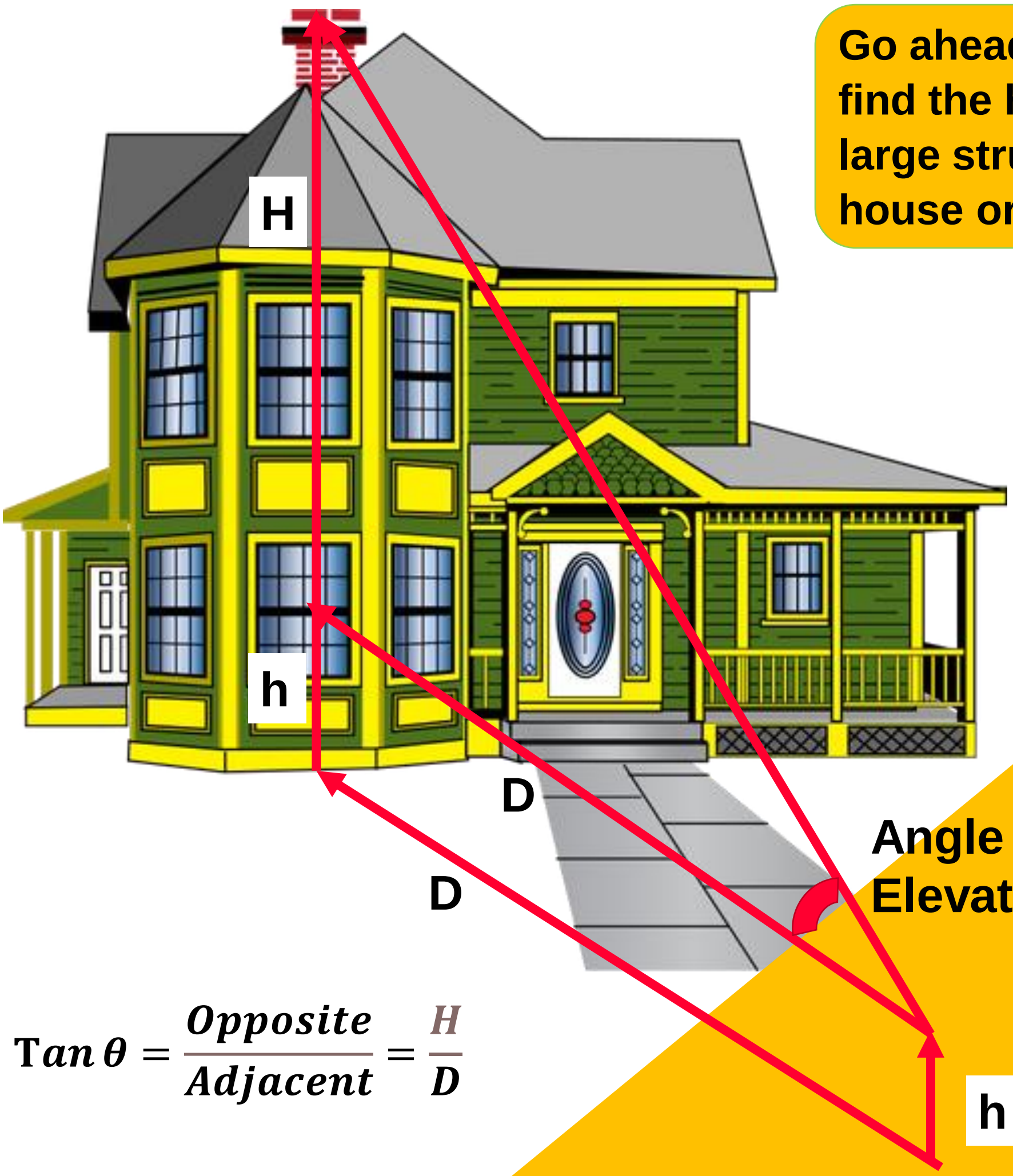
TRIGONOMETRY TABLE FOR SINE COS TAN VALUES

Angle A	Sin(A)	Cos(A)	Tan(A)	Angle A	Sin(A)	Cos(A)	Tan(A)
0	0.000	1.000	0.000	90	1.000	0.000	Undefined
2	0.035	0.999	0.035	92	0.999	-0.035	-28.636
4	0.070	0.998	0.070	94	0.998	-0.070	-14.301
6	0.105	0.995	0.105	96	0.995	-0.105	-9.514
8	0.139	0.990	0.141	98	0.990	-0.139	-7.115
10	0.174	0.985	0.176	100	0.985	-0.174	-5.671
12	0.208	0.978	0.213	102	0.978	-0.208	-4.705
14	0.242	0.970	0.249	104	0.970	-0.242	-4.011
16	0.276	0.961	0.287	106	0.961	-0.276	-3.487
18	0.309	0.951	0.325	108	0.951	-0.309	-3.078
20	0.342	0.940	0.364	110	0.940	-0.342	-2.747
22	0.375	0.927	0.404	112	0.927	-0.375	-2.475
24	0.407	0.914	0.445	114	0.914	-0.407	-2.246
26	0.438	0.899	0.488	116	0.899	-0.438	-2.050
28	0.469	0.883	0.532	118	0.883	-0.469	-1.881
30	0.500	0.866	0.577	120	0.866	-0.500	-1.732
32	0.530	0.848	0.625	122	0.848	-0.530	-1.600
34	0.559	0.829	0.675	124	0.829	-0.559	-1.483
36	0.588	0.809	0.727	126	0.809	-0.588	-1.376
38	0.616	0.788	0.781	128	0.788	-0.616	-1.280
40	0.643	0.766	0.839	130	0.766	-0.643	-1.192
42	0.669	0.743	0.900	132	0.743	-0.669	-1.111
44	0.695	0.719	0.966	134	0.719	-0.695	-1.036
46	0.719	0.695	1.036	136	0.695	-0.719	-0.966
48	0.743	0.669	1.111	138	0.669	-0.743	-0.900
50	0.766	0.643	1.192	140	0.643	-0.766	-0.839
52	0.788	0.616	1.280	142	0.616	-0.788	-0.781
54	0.809	0.588	1.376	144	0.588	-0.809	-0.727
56	0.829	0.559	1.483	146	0.559	-0.829	-0.675
58	0.848	0.530	1.600	148	0.530	-0.848	-0.625
60	0.866	0.500	1.732	150	0.500	-0.866	-0.577
62	0.883	0.469	1.881	152	0.469	-0.883	-0.532
64	0.899	0.438	2.050	154	0.438	-0.899	-0.488
66	0.914	0.407	2.246	156	0.407	-0.914	-0.445
68	0.927	0.375	2.475	158	0.375	-0.927	-0.404
70	0.940	0.342	2.747	160	0.342	-0.940	-0.364
72	0.951	0.309	3.078	162	0.309	-0.951	-0.325
74	0.961	0.276	3.487	164	0.276	-0.961	-0.287
76	0.970	0.242	4.011	166	0.242	-0.970	-0.249
78	0.978	0.208	4.705	168	0.208	-0.978	-0.213
80	0.985	0.174	5.671	170	0.174	-0.985	-0.176
82	0.990	0.139	7.115	172	0.139	-0.990	-0.141
84	0.995	0.105	9.514	174	0.105	-0.995	-0.105
86	0.998	0.070	14.301	176	0.070	-0.998	-0.070
88	0.999	0.035	28.636	178	0.035	-0.999	-0.035
90	1.000	0.000	Undefined	180	0.000	-1.000	0.000

Height of a building



Go ahead and try to find the height of a large structure like a house or a building

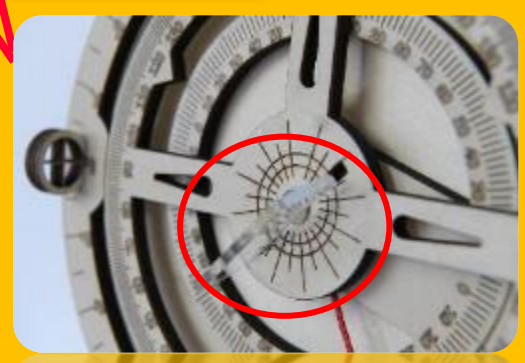
Angle of Elevation θ

$$\mathbf{Tan}\,\theta = \frac{Opposite}{Adjacent} = \frac{H}{D}$$

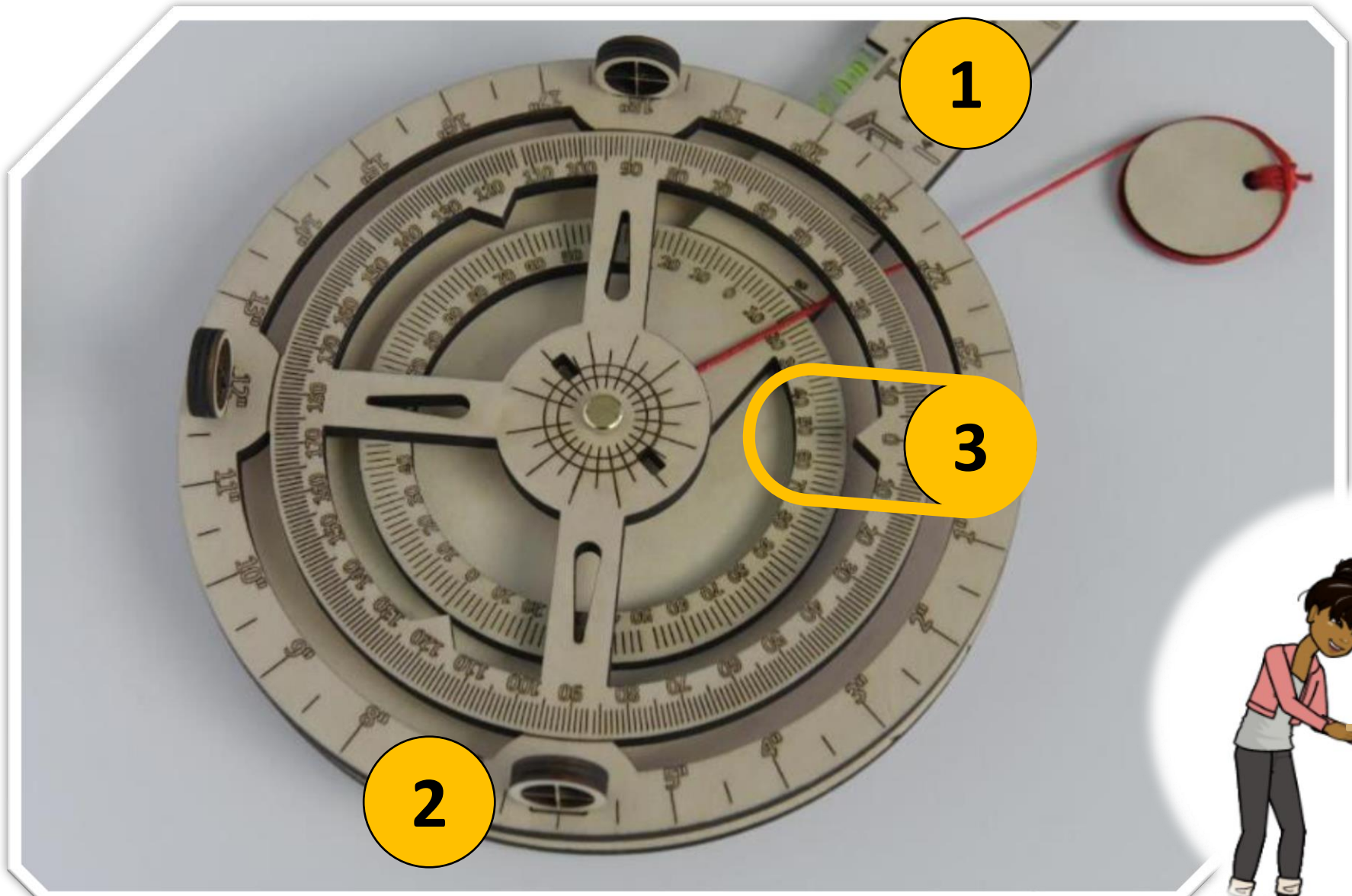
Calculations

Ground level angle measurement

To measure angle of elevation from ground level, attach the **reflector insert** to the outer dial. Aim and view the target through the top scope.



Horizontal measurements



1. **Hold outer dial flat or horizontal using the bubble level as your guide.**

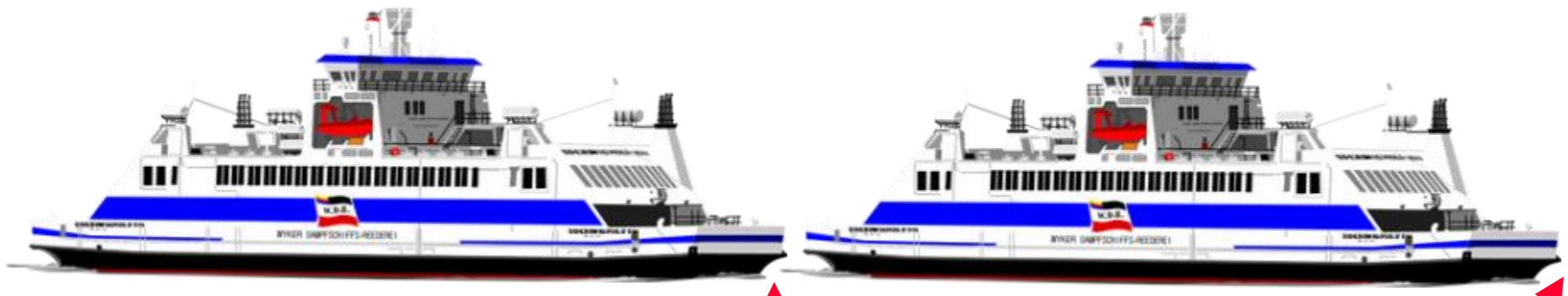
2. **Aim using the scopes as you normally would, adjust your aim to line up the object of interest and the 2 scopes so they are in a straight line.**

3. **Before turning the scope to the next object note the 0 point of the outer against the inner dial angle. Now turn the outer dial to aim at the next object and note the difference in the inner dial readings.**

If you turn both dials relative to each other, relative angle displacements must be calculated and used. For ease, keep the handle dial or inner dial fixed and rotate only the outer scope dial.

Example: If outer dial's 0 deg point was at 60 degrees on the inner dial and after turning outer dial is at 80 or 40. Then the angle between objects from your view point is = 20 degrees

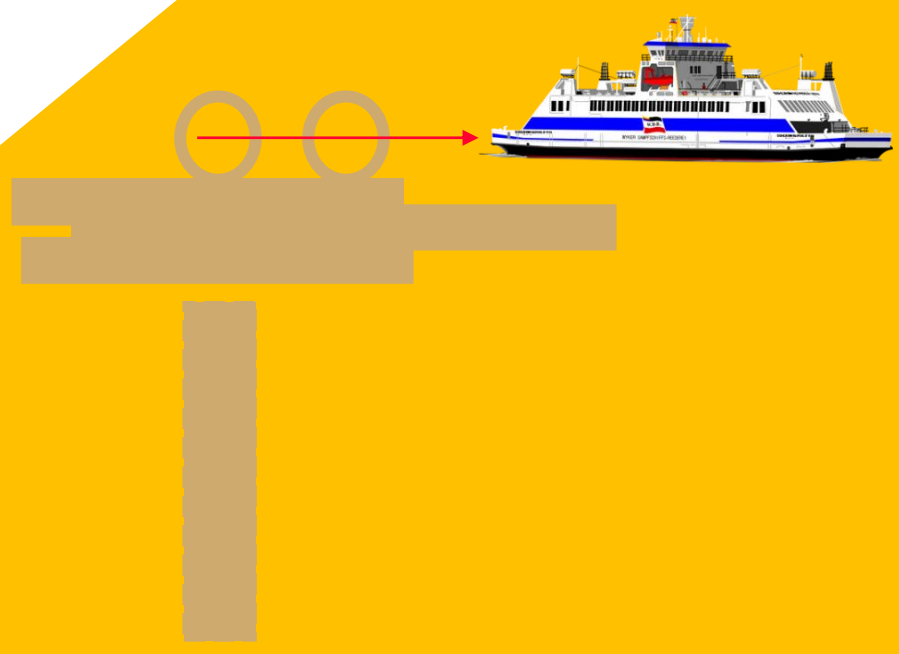
Horizontal measurement



Point 1

Point 2

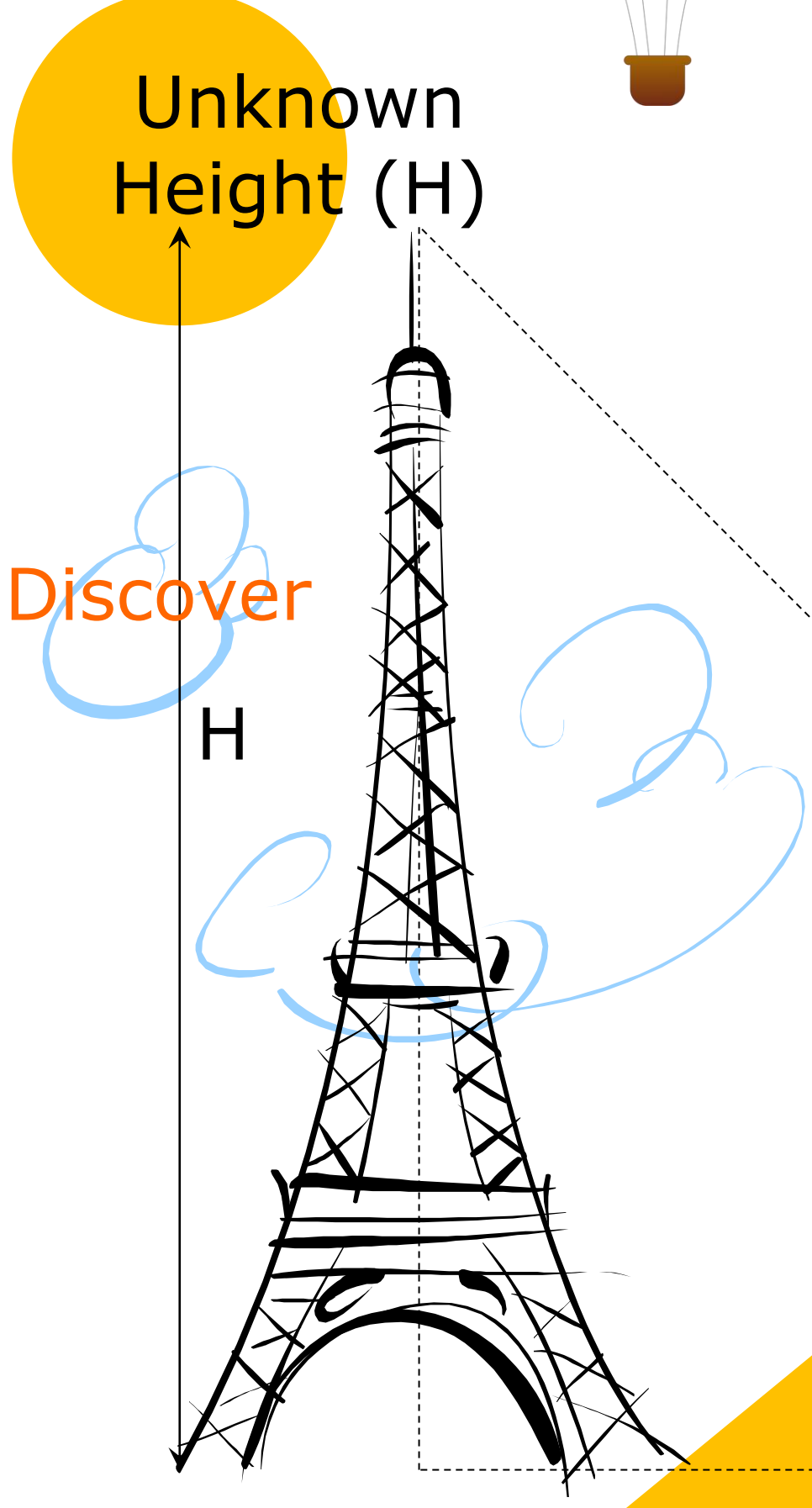
Try to keep the Trigmate in the same horizontal position while you move to observe the angles. Hold and operate Trigmate as if it was connected to a vertical stand on the ground



With a stop watch, you can calculate the time taken for the change in the angle. If you know the length of the ship you can find its speed.

ANY HEIGHT MEASUREMENT

Using Trigmate you can estimate the height of several objects, even flying objects!



Angle from Trigmate (θ)

Aim

Measure L = Length using Trigmate

THERE ARE FEW MORE WAYS TO APPLY TRIGMATE. DOWNLOAD THE TRIGMATE HANDBOOK FOR FREE AT Trigmate.com/pages/download

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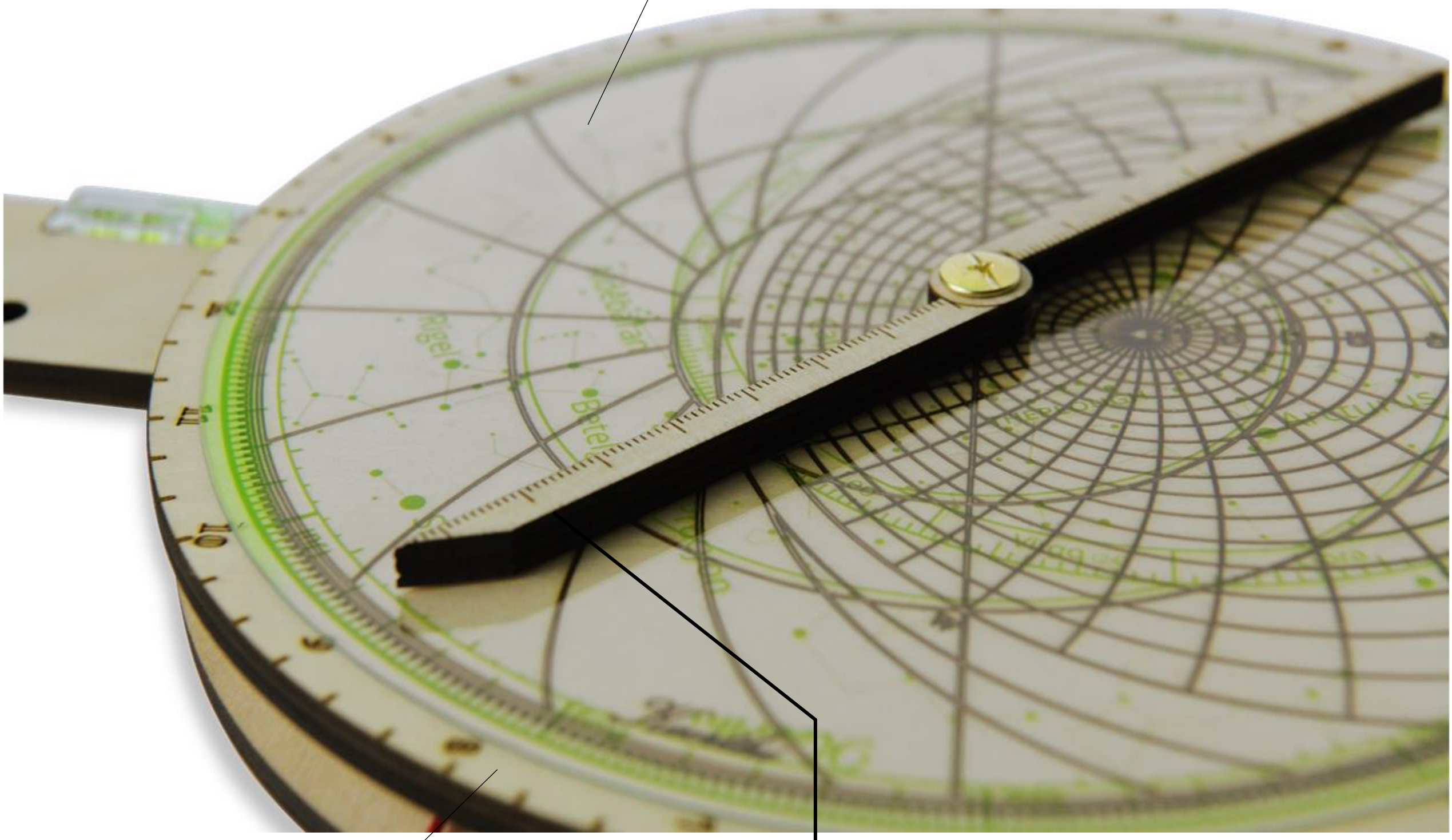
EZ-ASTROLABE

DOWNLOAD THE EXTENDED HANDBOOK FOR FREE AT
Trigmate.com/pages/download

Star Map
(Celestial Disc
or Rete)



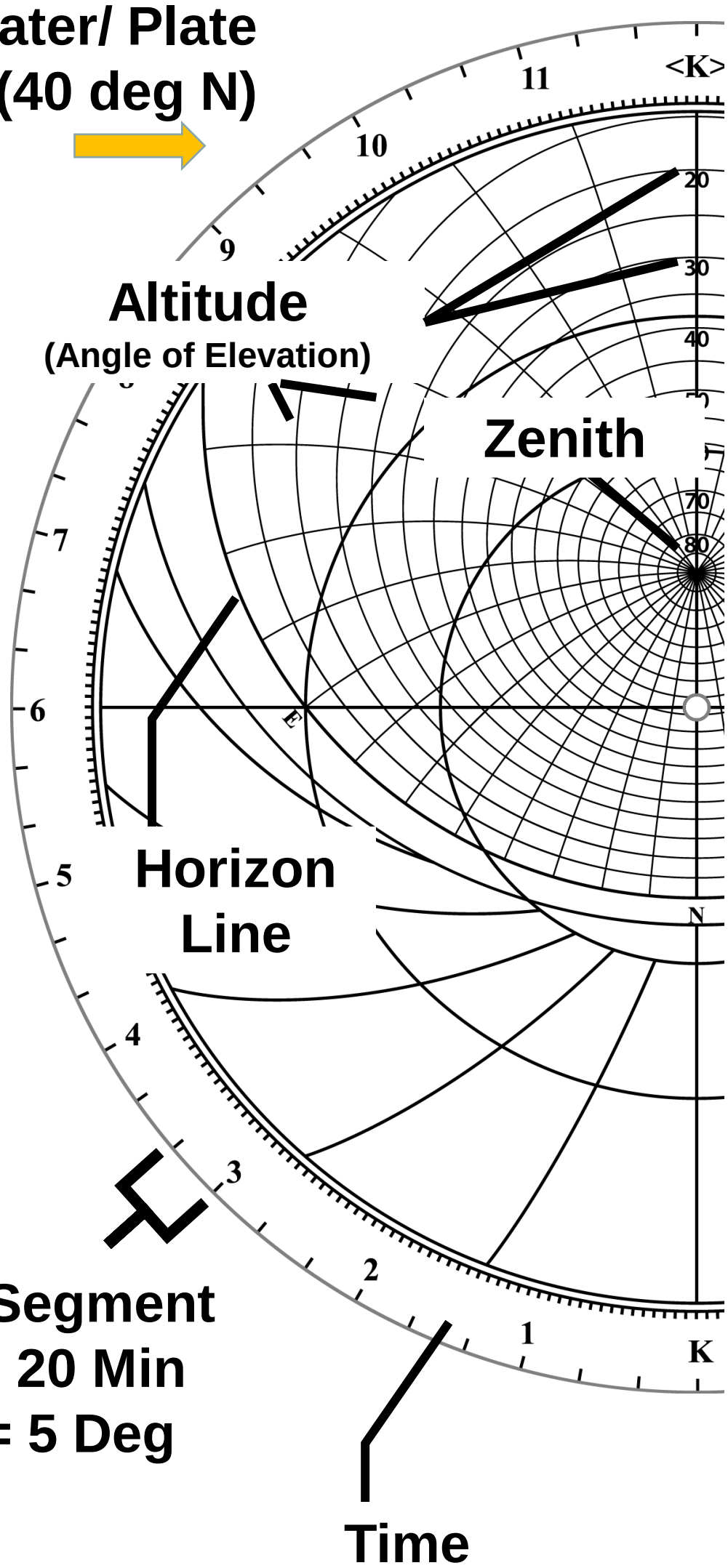
Altitude,
And Time
(Mater Plate)

Rule

EZ-ASTROLABE

Mater/ Plate (40 deg N)

Star Map or Rete/ Celestial Disc



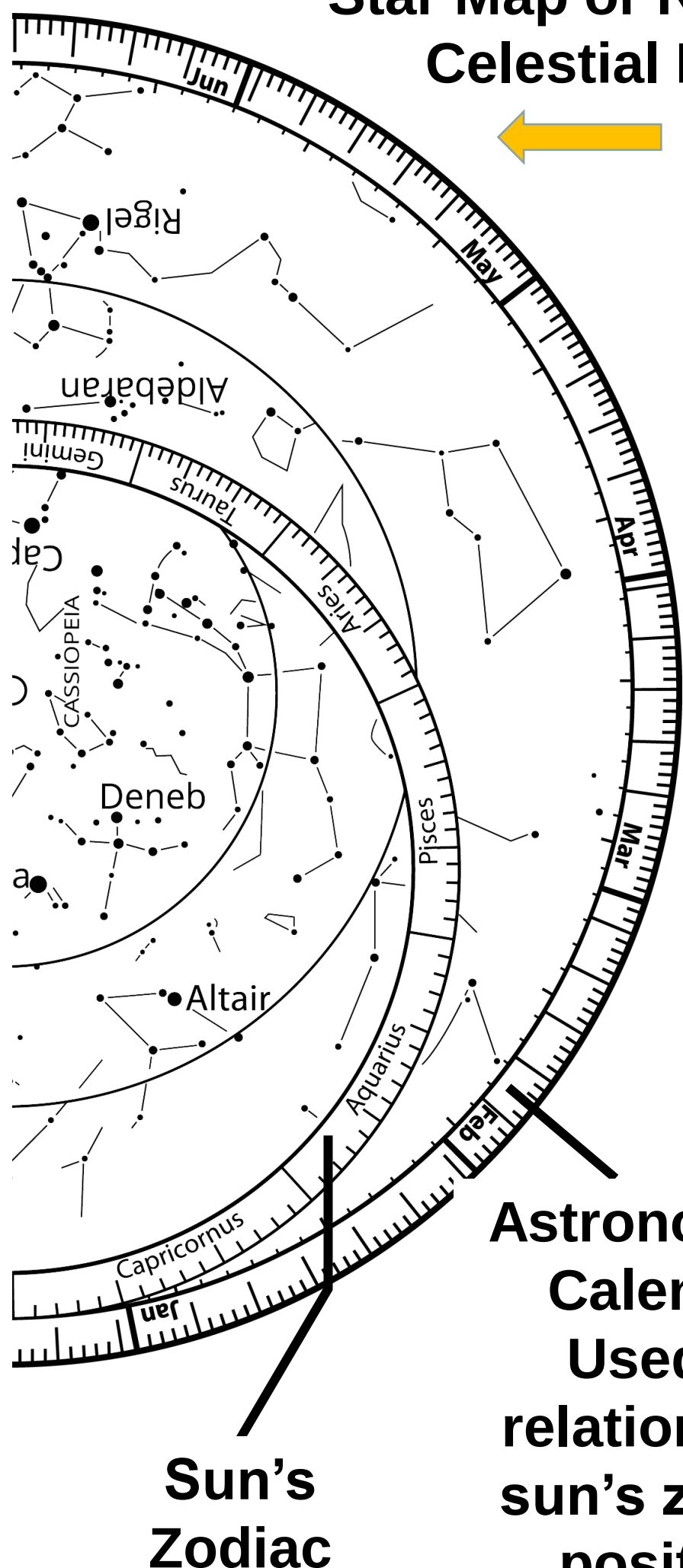
Altitude
(Angle of Elevation)

Zenith

Horizon Line

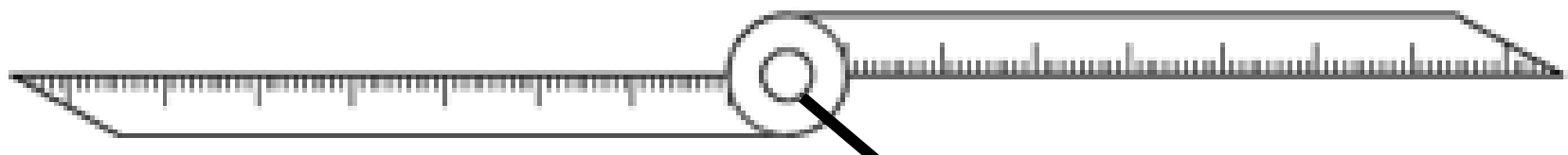
1 Segment = 20 Min = 5 Deg

Time



Sun's Zodiac position

Astronomical Calendar Used in relation with sun's zodiac position



Rule

EZ-ASTROLABE

WARNING: Never Look at the Sun directly to measure as it will ruin your eyes!

Calculating the Time

The scope sight serves as the alidade of the astrolabe to measure elevation of sun and stars or constellations.

Keep adjusting or turning the scope/alidade until a ray of sunlight shines through the 2 sights onto the palm of your hand or on your clothing and **casts a shadow of the 2 scopes. Have the shadow of the 2 horizontal scopes align exactly over your t-shirt for example!**

Without moving the scope, read the **angle of elevation** or altitude. Read the angle value where **the string cuts on the outer dial angle** noted in degrees. **Remember this observed angle – it's the angle of elevation.**

Turn the Trigmate to the astrolabe face. Rotate the rule on top of the Star map or Rete to point to the current day. For example if current day is April 2nd, point the rule to it. Now on the star map or rete, mark or locate where the rule cuts the sun's zodiac orbit (the off center circle). **This is suns position on that day**. Using a post-it note or temporary marker make a note of this spot.

Now turn the Rete/star map and the rule together so **this suns position** matches the observed angle of elevation **on the altitude lines or almucantars.** That's the time before DL time savings. The hours go from 0 to 12 for the time. For example 6 -12 = 90degrees, or 18 segments, each segment = 5 degrees or 20 min.

EZ-ASTROLABE

Observing Constellations in the Night Sky

Using current date, locate the sun’s zodiac position on the star map. If time at night is known, rotate sun’s location using the rule to position it by the time. Remember, no day light changes were used back then.

For example; If we take early February for this example, we will need to note sun’s position in the middle of Capricorn. And if we want to set the astrolabe to 10pm, we turn the celestial disk until the sun is in the lower right of the astrolabe, lined up with the 10pm mark. We can use the rule to help make precise alignments.

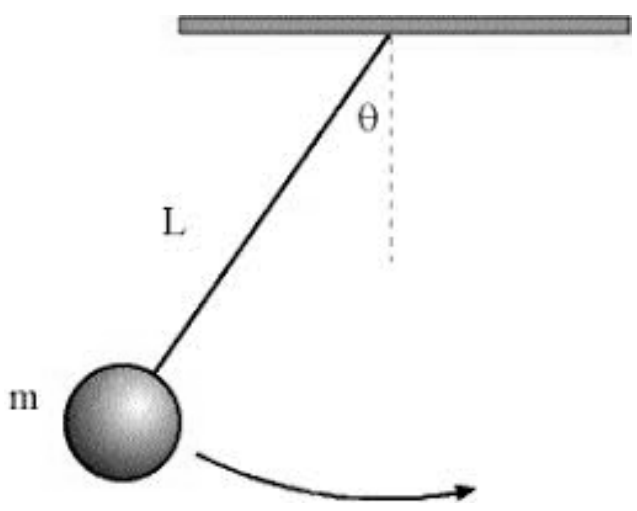
This lays out the constellations on the star map for that particular night. You can make more precise adjustments by using the scope to aim at the noted constellations on the star map, recording the star’s elevation angle (just like finding it for out star the sun) and aligning it to the elevation altitude on the plate.

This last step of locating the stars can also be used to find the time at night, using the current date.

Laws of Pendulum

Pendulum is a body suspended from a fixed point allowing it to swing back and forth under the influence of gravity.

Pendulums were used to regulate the movement of clocks because the interval of time for each complete oscillation, called the period, is constant, now that's pretty cool don't you think ?



The formula for the period T of a pendulum is

$T = 2\pi\sqrt{(L/g)}$,

Where L is the length of the pendulum and g is the acceleration due to gravity. Vary the string length and use a watch (seconds) to confirm T.

L

Add extra weights "m" to the pendulum, and hang Trigmate or use books to make it stable.

Ensure the string is able to move or oscillate freely without touching the dials.

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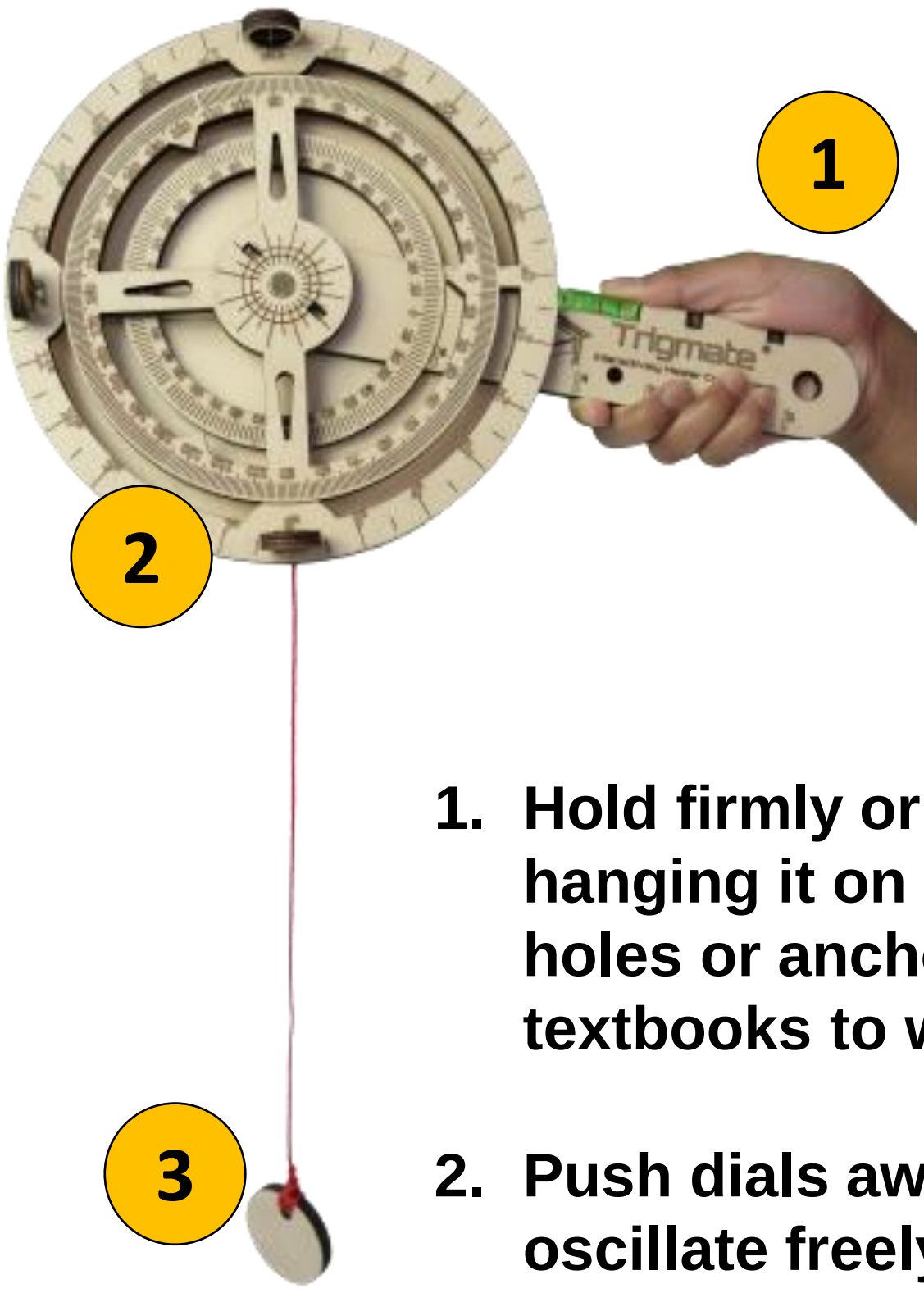
Pendulum setup



Use Large books on a table to anchor Trigmate or a wall hook to hang Trigmate to do these experiments

1. **Hold firmly or secure Trigmate by hanging it on a wall hook by the handle holes or anchor it down on a table. Use textbooks to weigh it down.**

2. **Push dials away from the string so it can oscillate freely. Rotate the dial so the zero is at the top or bottom, it helps with measuring oscillation angles.**

3. **Ensure a long string is tied to the pendulum weight and is taut. Pull back the weight while string is taut and release, check if string oscillates freely.**

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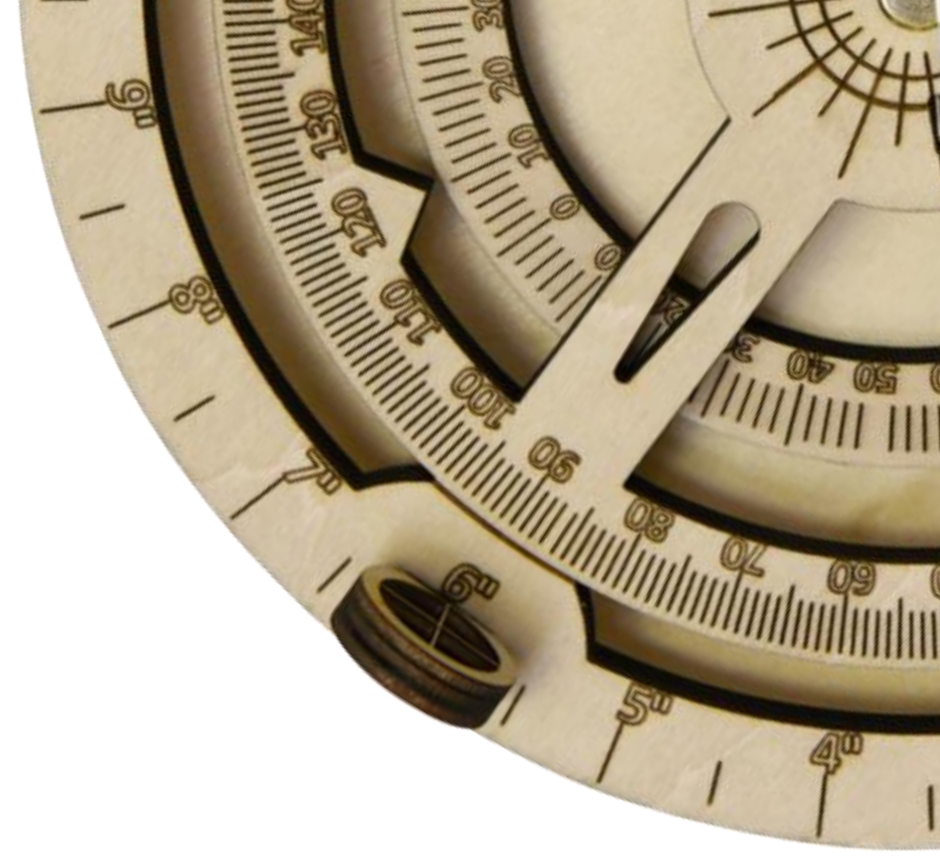
Try different string length and analyze the results



“For small creatures such as we the vast universe is bearable only through love.”

— Carl Sagan, Contact

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Write to us at
learn@trigmate.com