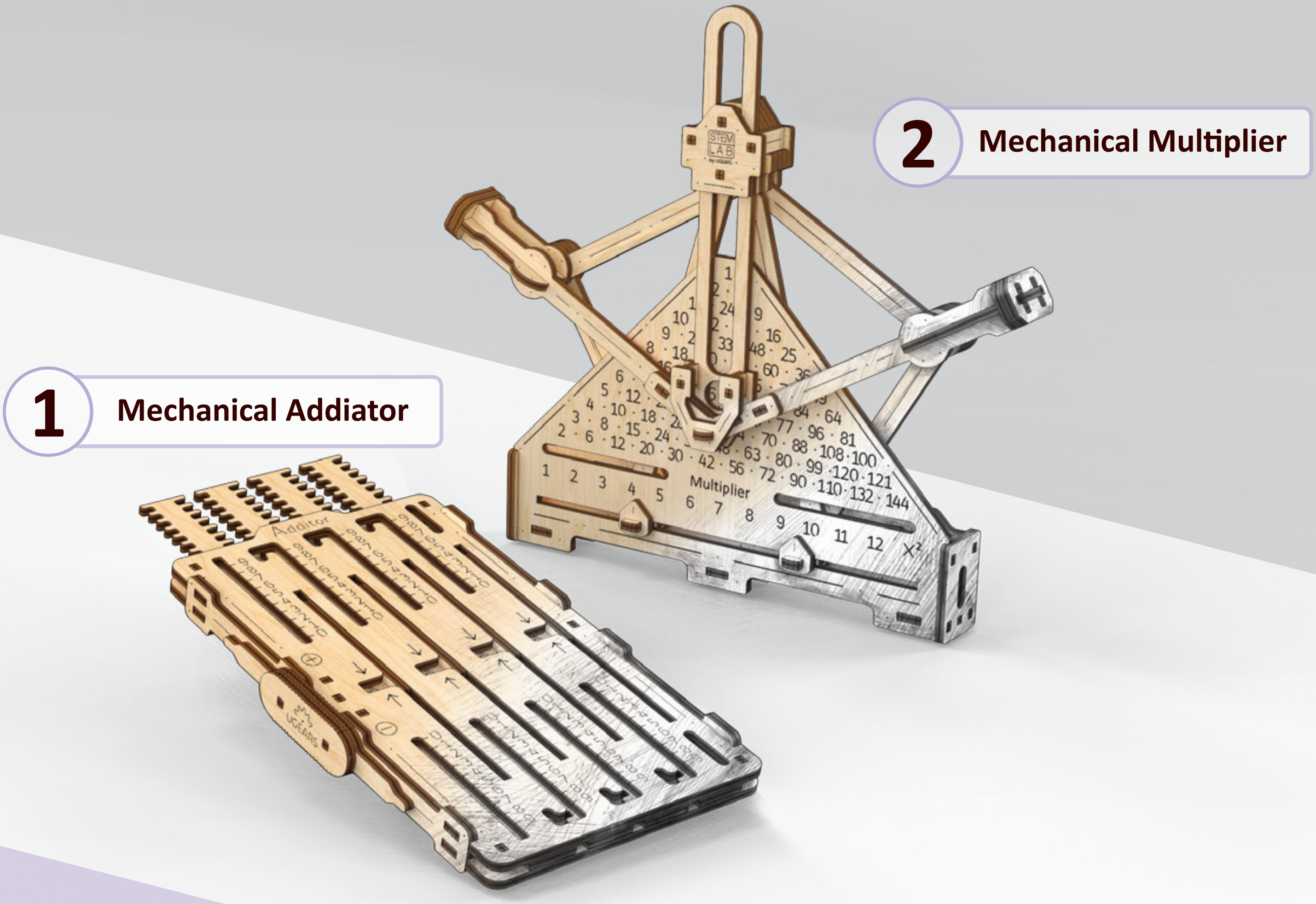
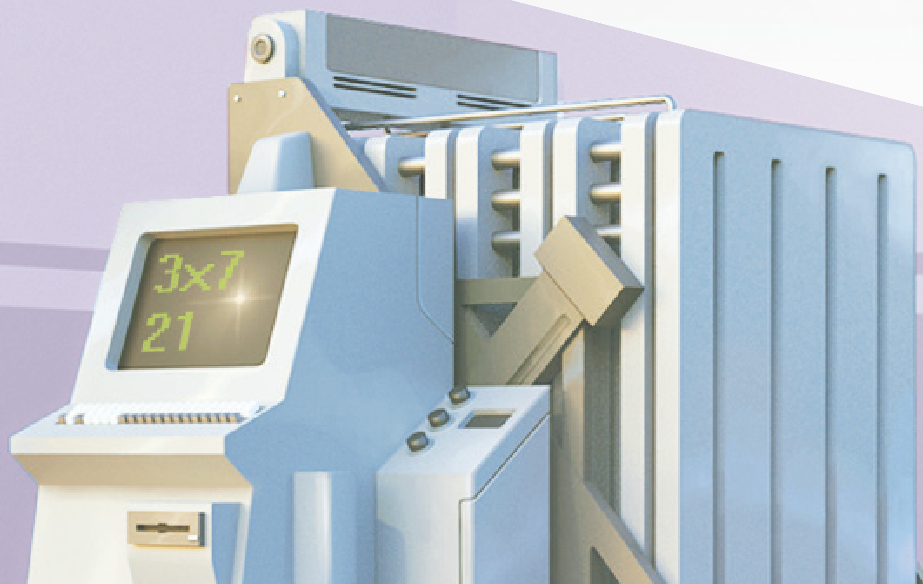
STEM LAB by UGEARS

MECHANICAL MODEL

ARITHMETIC 2-IN-1 KIT

Handbook for a Young Engineer





ANDROID APP ON Google play

Available on the iPhone App Store

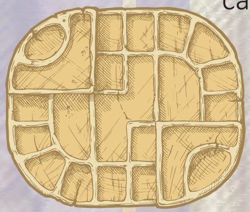
§1 Introduction

Numeracy is an important skill. More than just important, it's a basic, foundational skill. It's unlikely you've ever met a person who doesn't know how to count (except the smallest of children). People count everything around them, without even thinking. We add, subtract, multiply and divide. At first glance, there is nothing complicated about this. Everyone learned to count on their fingers, in their mind, or in columnar form on paper, either at their mother's knees or in their earliest school classes. Who can forget memorizing the multiplication tables in elementary school? As we progress to middle and high school, calculators enter the classroom, to simplify the task of performing basic calculations and enable us to perform more complex mathematical operations. As we become adults, numeracy continues to play an important role in every aspect of human life—from simple everyday communications and transactions, to politics and global trade.

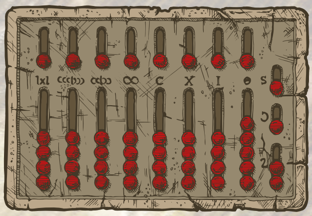
Scientists say that numeracy originated with prehistoric humans known as the Cro-Magnons, during the Stone Age. As civilization developed, a practical need arose for numeracy and calculation, primarily due to accounting tasks arising during the centralization of agriculture. This is how arithmetic appeared—a branch of mathematics that studies numbers, their properties and calculation techniques. The tasks associated with numeracy gradually became more complicated, driving further development of arithmetic—addition, subtraction, multiplication, division, and other operations and branches of mathematics.

This mathematical advancement in turn stimulated the development of various aspects of human activity, and vice versa. Greek mathematicians played an important role in the development of arithmetic, for example, the Pythagorean philosophers of the fifth and fourth centuries B.C.E. who described important laws using numbers and established the importance of numbers to understanding music and the cosmos.

For a long time, people have used various methods and devices to perform arithmetic operations. The increasing complexity and growing volume of arithmetic operations people had to perform prompted the development of special devices to facilitate calculations.



Yupana, Inca Empire



Roman abacus

Schoty, Russia

Suanpan, China

Soroban, Japan

Two such devices, shown above, are found in the Arithmetic Kit from Ugears' educational STEM Lab collection of models. These amazing devices will help you with many calculations.

Cro-Magnon is a common name for ancient humanity. They are considered the ancestors of Euro-peans and appeared about 40,000 years ago. It is believed that visually and physically, Cro-Magnons did not differ much from modern people.

§2 Historical background

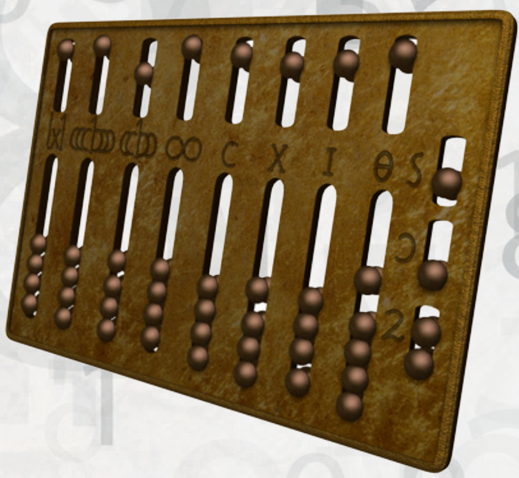
Mechanical Multiplier, which we will discuss in more detail later.

But first let's figure out how calculating machines developed historically, and what were the prerequisites for creating devices that helped us to count.

First, early humans made determinations of things as to their quantity. Numbers and digits may not have existed yet, but people already counted things—this is "one house," these are "two fish" or "three enemies," and so on.

Later, people learned to count higher numbers by bending their fingers, making notches on bone with stone tools, or putting pebbles, planks, beads, and other things in a certain order.

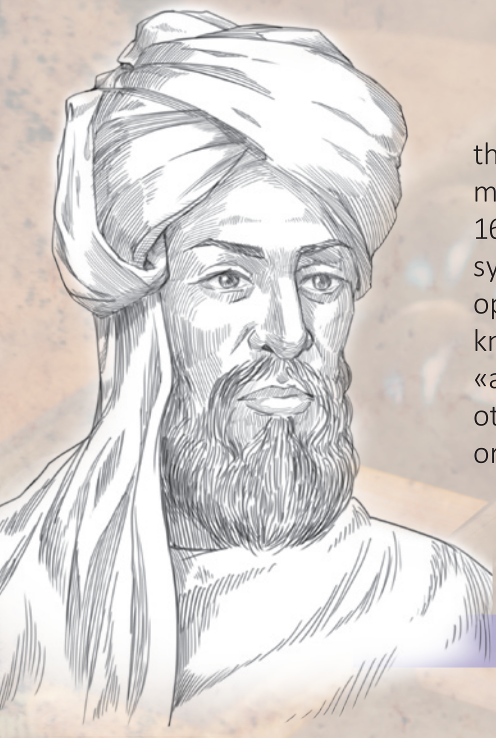
The first known computing devices appeared in Sumeria in the third millennium B.C., almost 5,000 years ago! Various civilizations possessed calculation devices, some invented independently, others spread through foreign influence brought by trade. One notable example of an ancient counting device is the Salamis Tablet, in use on the island of Salamis in the Aegean Sea in 300 B.C., The abacus presents a fascinating example of the spread of technology, with different versions appearing in Ancient Egypt, Persia, Greece, Rome and other parts of Western Europe. The Chinese version of the abacus, or «suanpan,» arose in the 2nd century B.C. and was imported to Japan as the «soroban» in the 14th century A.D. What these different abacuses have in common is that they are boards made of various materials (bronze, stone, wood, ivory, colored glass, etc.) with special grooves into which one could move beads and pebbles by which calculations were carried out. Europeans used the abacus until the Renaissance, and there are parts of the world, particularly in Asia, where you can walk into a shop and see an abacus still in use today.



Roman / ancient Greek abacus

Another interesting example of counting devices are the ancient "talking knots" and "quipu" of the Incas and other peoples living on the American continents.

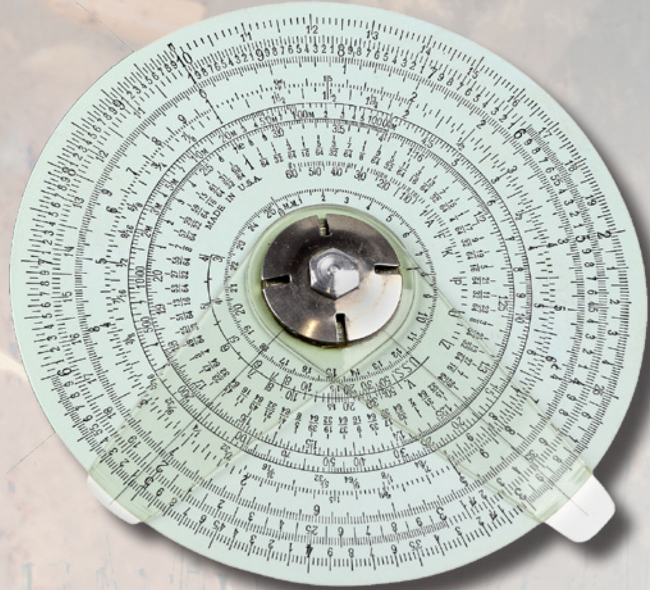
Talking knots



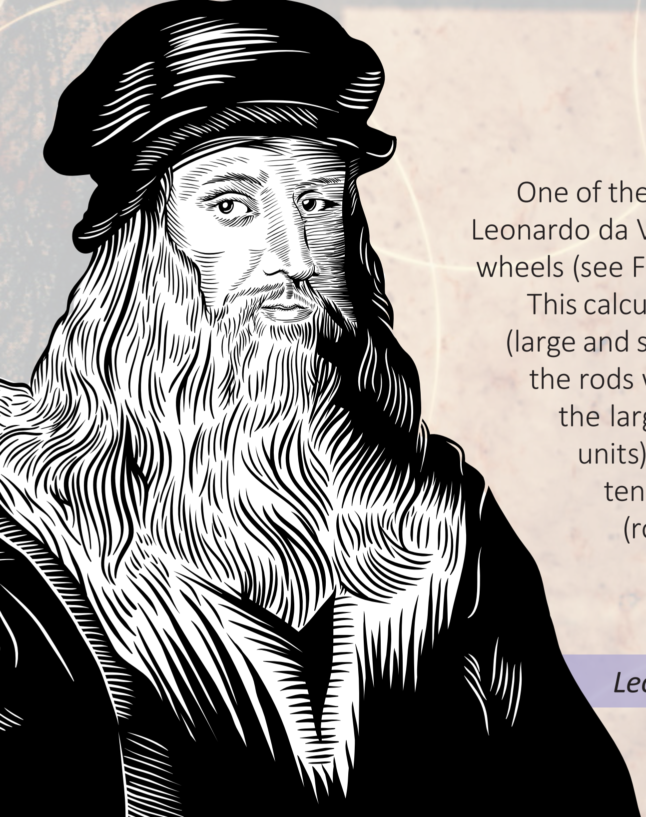
In the 9th century A.D., Uzbek scientist Mohammad ibn Musa al-Khwarizmi wrote the "Compendious Book on Calculation," which became the dominant textbook on mathematics for seven hundred years, being used in European universities into the 16th Century. In his treatise, the great Uzbek scientist described the decimal number system, which came to the Arabs from India. He also described four arithmetic operations: addition, subtraction, multiplication, and division, which became widely known all over the world and are obviously used to this day. Intriguingly, the word «algorithm,» which means a process or set of rules for performing calculations or other problem-solving operations, derives from al-Khwarizmi's name (al-chorism or al-gorithm).

Mohammad ibn Musa al-Khwarizmi

As mathematics continued to develop rapidly, new devices for calculating appeared steadily. After Scottish mathematician John Napier discovered logarithms in 1614, English mathematician William Oughtred invented the slide rule in 1622 (see Fig.) A concept close to the structure of a slide rule had previously been demonstrated at the beginning of the 17th century by English astronomer Edmund Gunter.



William Oughtred's slide rule model



One of the first projects of a mechanical calculating machine was developed by Leonardo da Vinci. He presented a sketch of a thirteen-bit adder with ten-toothed wheels (see Fig.)

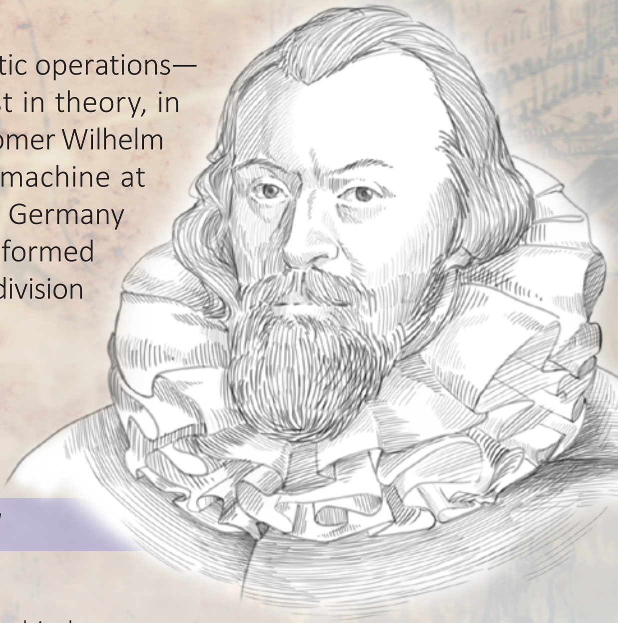
This calculating machine consisted of 13 rods with toothed wheels on each side (large and small), operated using weights. The principle of operation was simple: the rods were positioned so that the small wheel of the first rod meshed with the large wheel of the next rod. So, ten revolutions of the first rod (rod of units) led to one full rotation of the second rod (rod of tens), respectively, ten revolutions of the second rod led to one revolution of the third rod (rod of hundreds), and so on.

Leonardo da Vinci

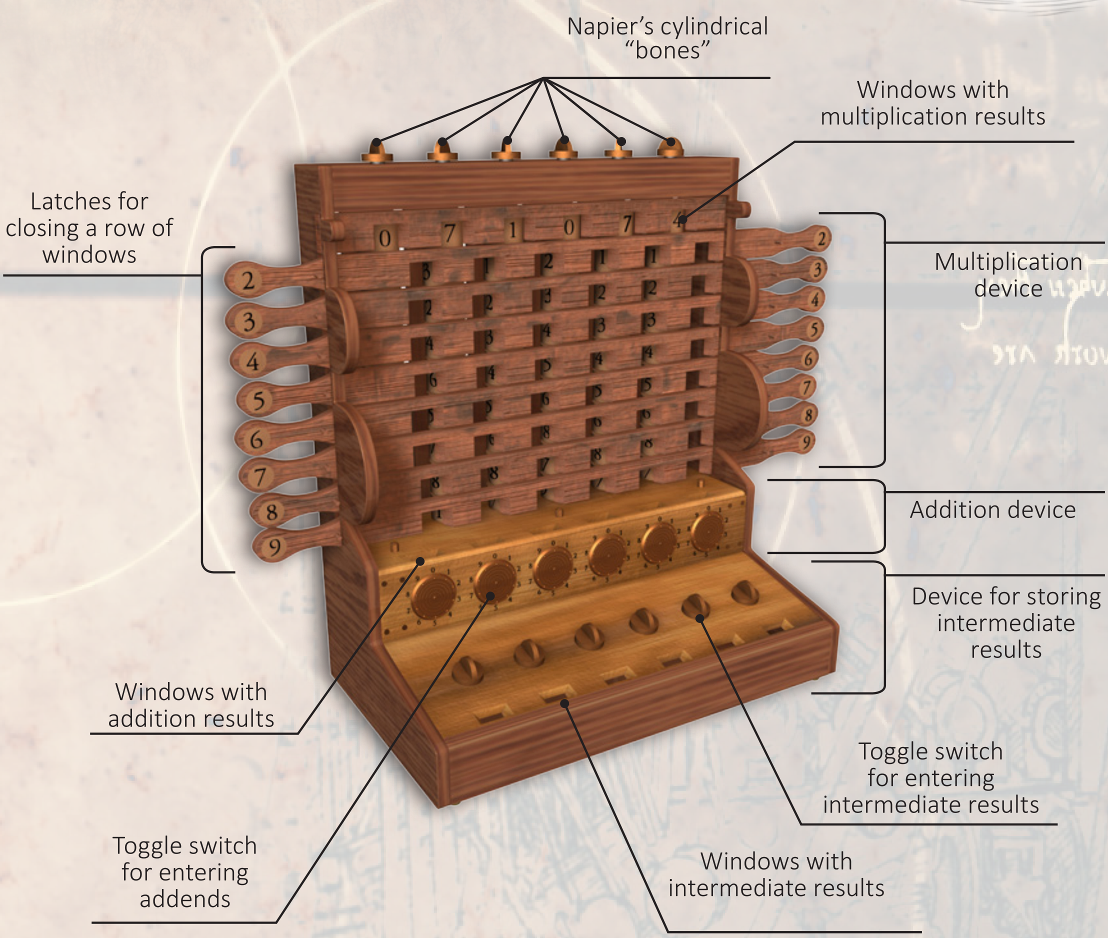
Draft of Leonardo da Vinci's calculating machine

That is, if we rotate the rod of units ten times, it will have a value of 0, and on the adjacent rod of tens there will be a value of 1. As a result, we obtain 10.

The first calculating machine that could perform four basic arithmetic operations—addition, subtraction, multiplication, and division—appeared, at least in theory, in 1623. The device was defined by the German mathematician and astronomer Wilhelm Schickard. It is still uncertain whether anyone built this calculating machine at that time, but in the 1960s scientists at the University of Thuringia in Germany built a device for calculations using Schickard's design. The machine performed addition and subtraction operations mechanically, but multiplication and division were carried out with elements of mechanization.



W. Shickard



W. Shickard's Calculating Machine

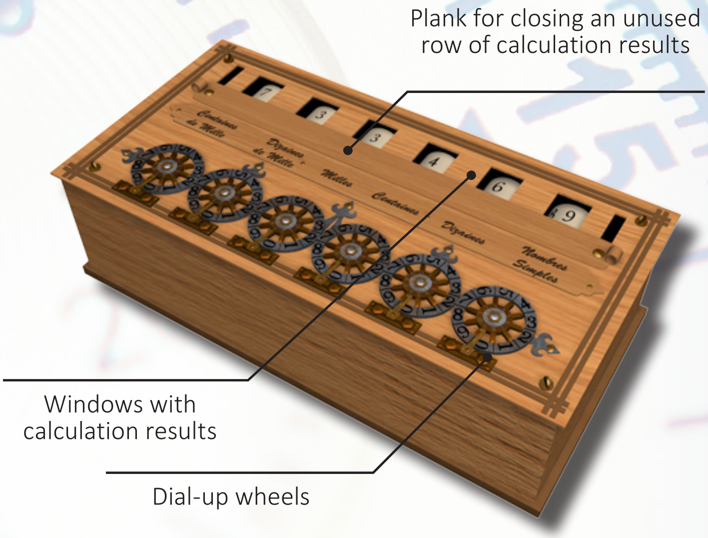
In 1642 French physicist and philosopher Blaise Pascal invented the Pascaline adding machine, which was created primarily for his father, who worked as a government finance auditor.

The Pascaline machine (see Fig.) is a small brass box (36x13x8 cm) that makes it possible to add and subtract

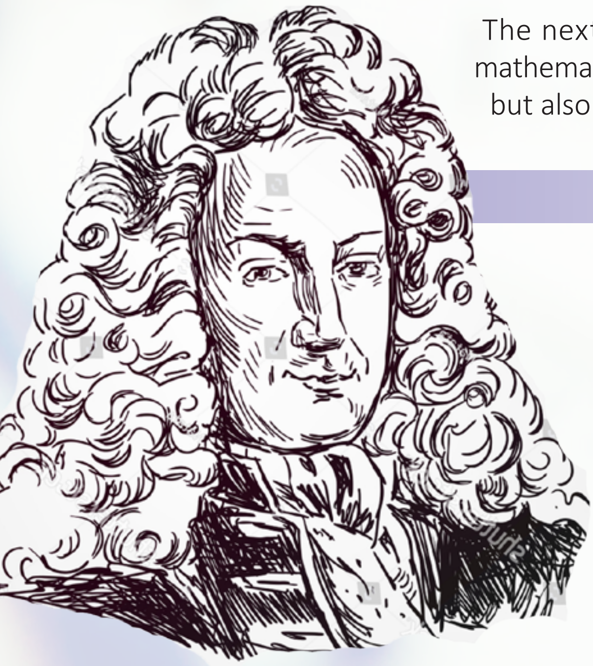
Blaise Pascal

Inside the box were gears connected to each other, and on top, there were several dial-up wheels that corresponded to digits, with marks from 0 to 9, as well as windows for displaying results.

There are more than 50 extant Pascaline machines, several of which are in museums in Paris.

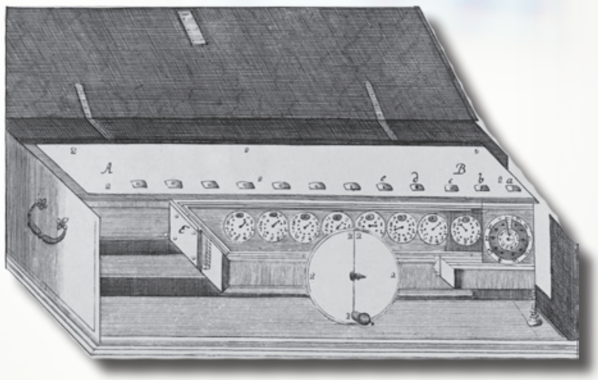


Pascaline machine



The next significant device was the computing machine invented by German mathematician Gottfried Wilhelm Leibniz (see Fig.). It could not only add and subtract but also multiply and divide.

Gottfried Wilhelm Leibniz



G. Leibniz's computing machine

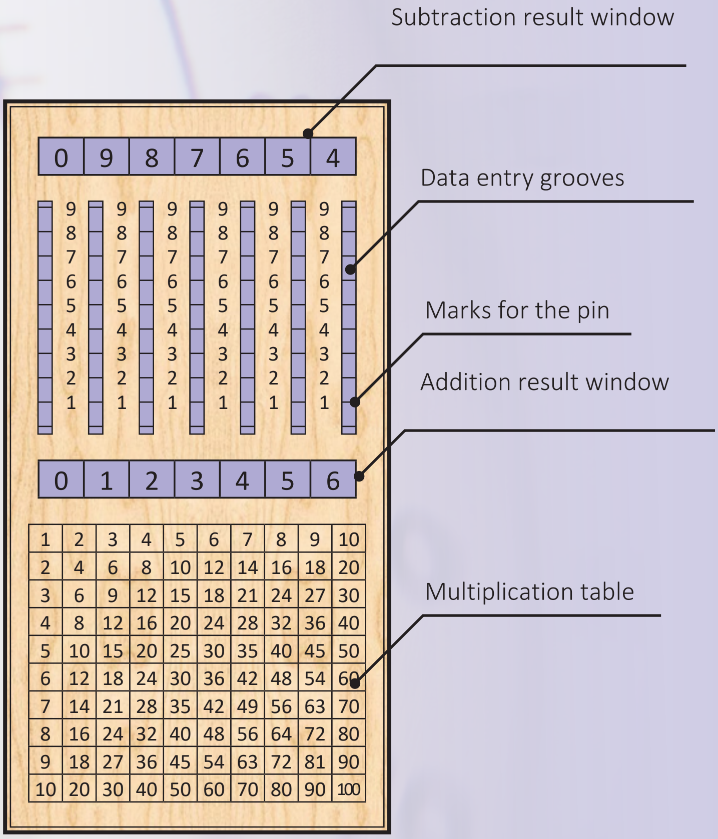
Toward the end of the 17th century, French scientist Claude Perrault (the brother of the famous storyteller Charles Perrault, who pioneered the fairy tale genre) invented the Rhabdological Abacus adding machine, in which he used toothed racks instead of toothed wheels (see Fig.).

This calculating machine was a plate on which seven grooves were cut with a scale of numbers from 1 to 9. They symbolized digits—units, tens, hundreds, thousands, and so on, up to millions. Each groove had marks that could be moved up and down with a pointed pin enabling addition and subtraction.

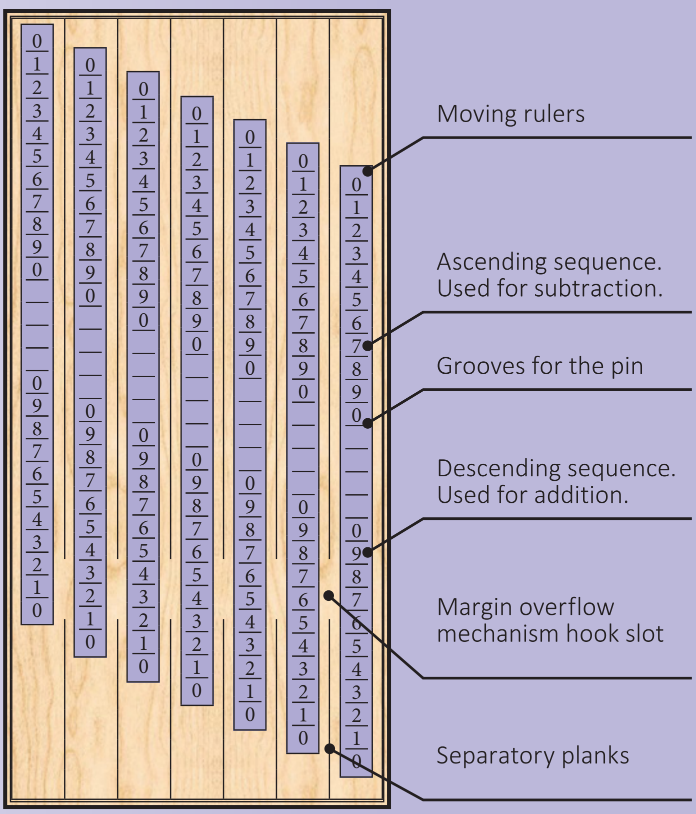
The results were displayed in special windows—separate for addition and subtraction. The multiplication table was also engraved on the plate.

Inside each plate, separating the groove-rulers from one another, was a hole used for margin overflow from the less significant digit to the more significant digit (see Fig.). This hole was located at the base of the ruler, moved to the very top of the device, and was three marks long. Margin overflow was performed using hooks (not shown in Fig.) located on the other side of the ruler (under marks 11 and 12, if you count from the bottom).

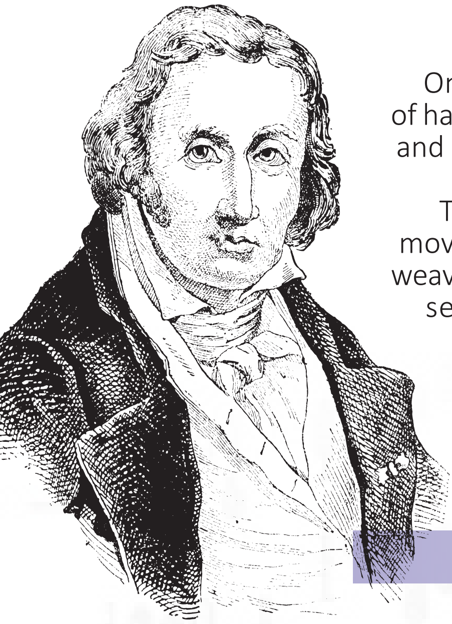
Claude Perrault



Rhabdological abacus, Top view



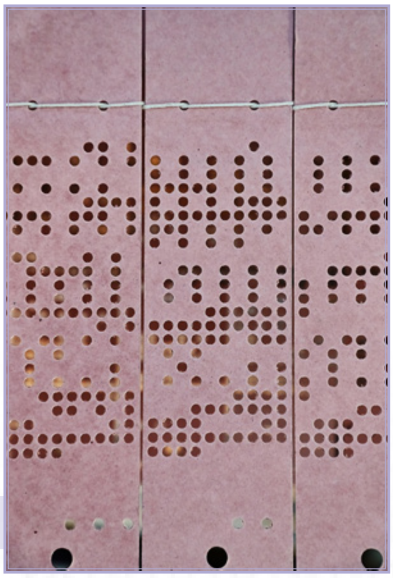
Rhabdological abacus, Internal



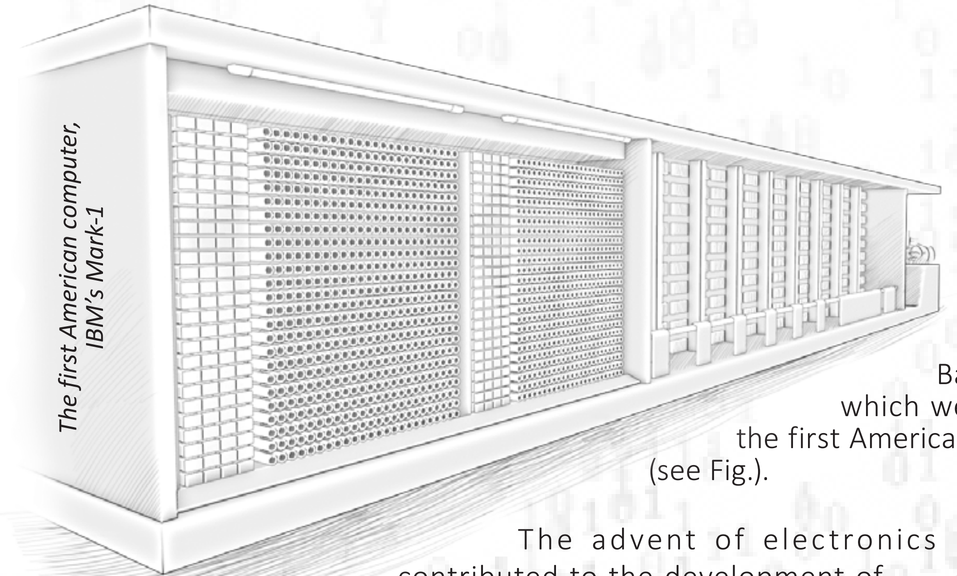
One of the first machines with punched card control of hardware was invented in 1804 by the French weaver and inventor Joseph Jacquard.

This mechanism, essentially a loom, automatically moved rods attached to hooks that grabbed threads to weave patterns in the cloth, according to the instructions set forth in a string of punched cards (cardboard cards with punched holes) (see Fig.). The beautiful, complex weave patterns of the Jacquard machine were accomplished as the loom «read» the information in these punched cards.

Joseph Jacquard



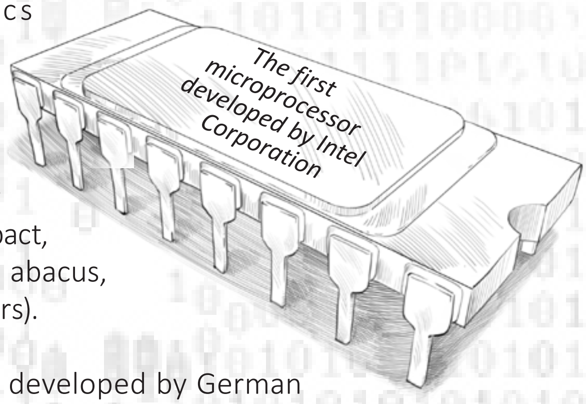
Jacquard's loom punched card kit



The first American computer, IBM's Mark-1

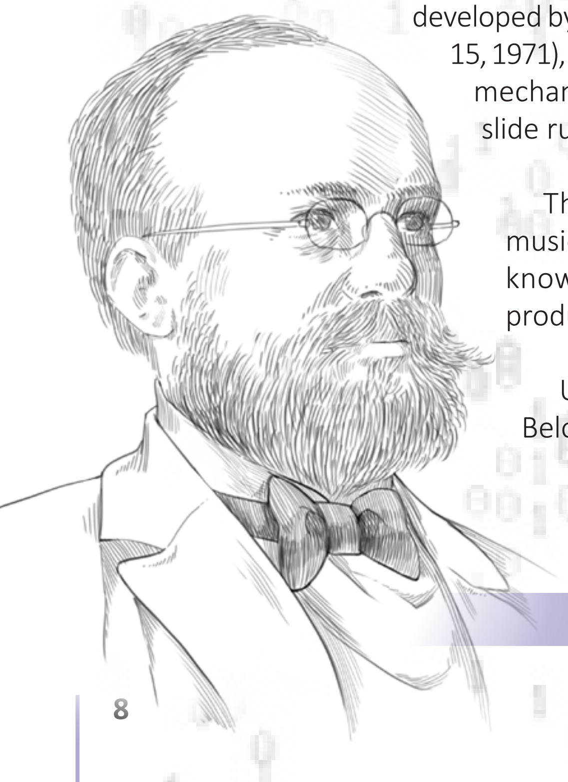
The principle of punched card control was picked up on by English mathematician Charles Babbage in developing his analytical machine. He worked on it for almost forty years, but could not complete what he started. Babbage left behind about 200 drawings which were used by Howard Aiken to develop the first American relay computer in 1941: IBM's Mark-1 (see Fig.).

The advent of electronics contributed to the development of computing devices accessible to consumers at reasonable prices, but in the days before microprocessors (the first microprocessor, developed by Intel, was released November 15, 1971), most people used simple, compact, mechanical computing devices (e.g., abacus, slide rules, arithmometers, and others).

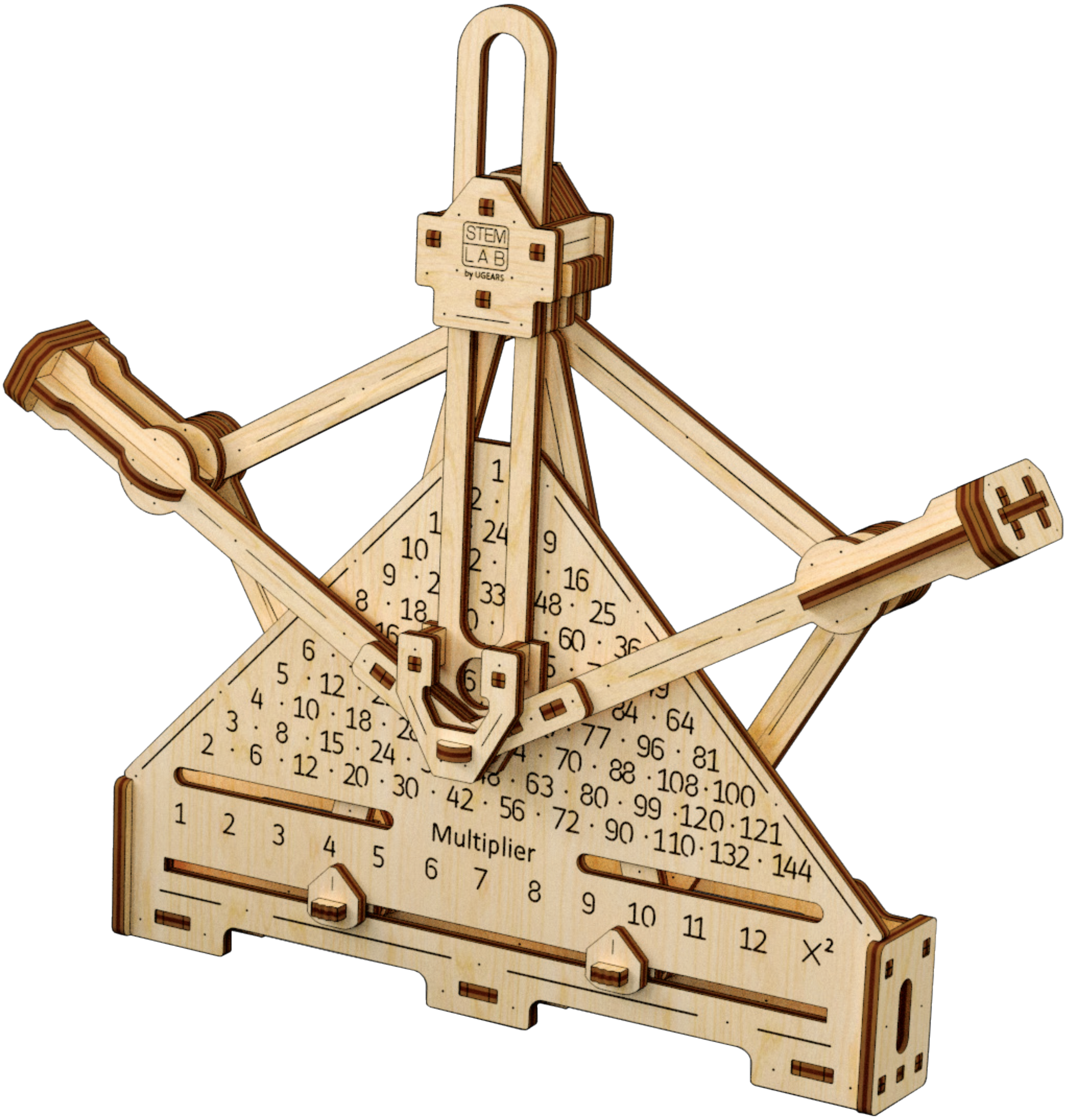


The slide adding machine was developed by German musician and inventor Heinrich Kummer in 1846, and became known as Kummer's Addiator. The device was in common use and produced until 1982.

Ugears' Mechanical Addiator is a modified version of Kummer's Addiator. Below, we will look at how it works in more detail.



Heinrich Kummer



But first, let's get acquainted with the story behind the historical prototype of the second model from our STEM Kit: the Mechanical Multiplier.

It all started with a trained monkey named Consul, who knew how to simulate many human actions, including operating a cash register. Consul's fame inspired the American scientist William Henry Robertson to create, in 1915, a toy called «Consul the Educated Monkey.» Robertson, a former high school math teacher, sought to invent a device that would help stimulate children's interest in learning numbers. The toy, fashioned like a monkey, was able to multiply and square numbers from 1 to 12. You may ask, "Why up to 12, and not up to 10, as in most school multiplication tables?» The answer is that in the British and American measurement systems, the number "12" plays an important role: one foot is equal to 12 inches, and until 1971, one shilling was equal to 12 pence. Therefore, the multiplication tables throughout the British empire historically had a dimension of 12 × 12.

Next, let's consider
our models in more detail.

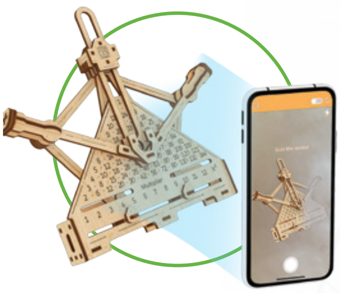
P. 11-19 - Mechanical Addiator.
P. 20-23 - Mechanical Multiplier.

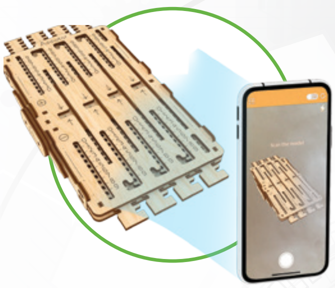
Unique AR experiences with the Mechanical Addiator and Mechanical Multiplier model; real life uses

1 Scan QR to download App

2 Open the application

3 Point and align the image on the screen with the model





4 Interact in AR

Each of the mechanical models in the UGEARS STEM Lab series is an interactive manual mechanism.

Assemble the Arithmetic kit with your own hands and find uses for Mechanical Addiator and the Mechanical Multiplier work, while learning their principles of operation.

Plunge into the world of augmented reality with the special UGEARS AR app. Just point your smartphone or tablet at one of the assembled models to see how the mechanism is used in real life. Interact with the models on the screen. Review the mechanisms from a variety of angles. Learn how the Mechanical Addiator and Mechanical Multiplier were used in early computing machines.

ANDROID APP ON Google play

Available on the iPhone App Store

Enjoy our unlimited support!
Should you have any questions about assembly, we are always here for you to suggest the best solution and provide the help you might need. Our 24/7 customer support service will accept and process your request promptly and professionally.

Customer support:
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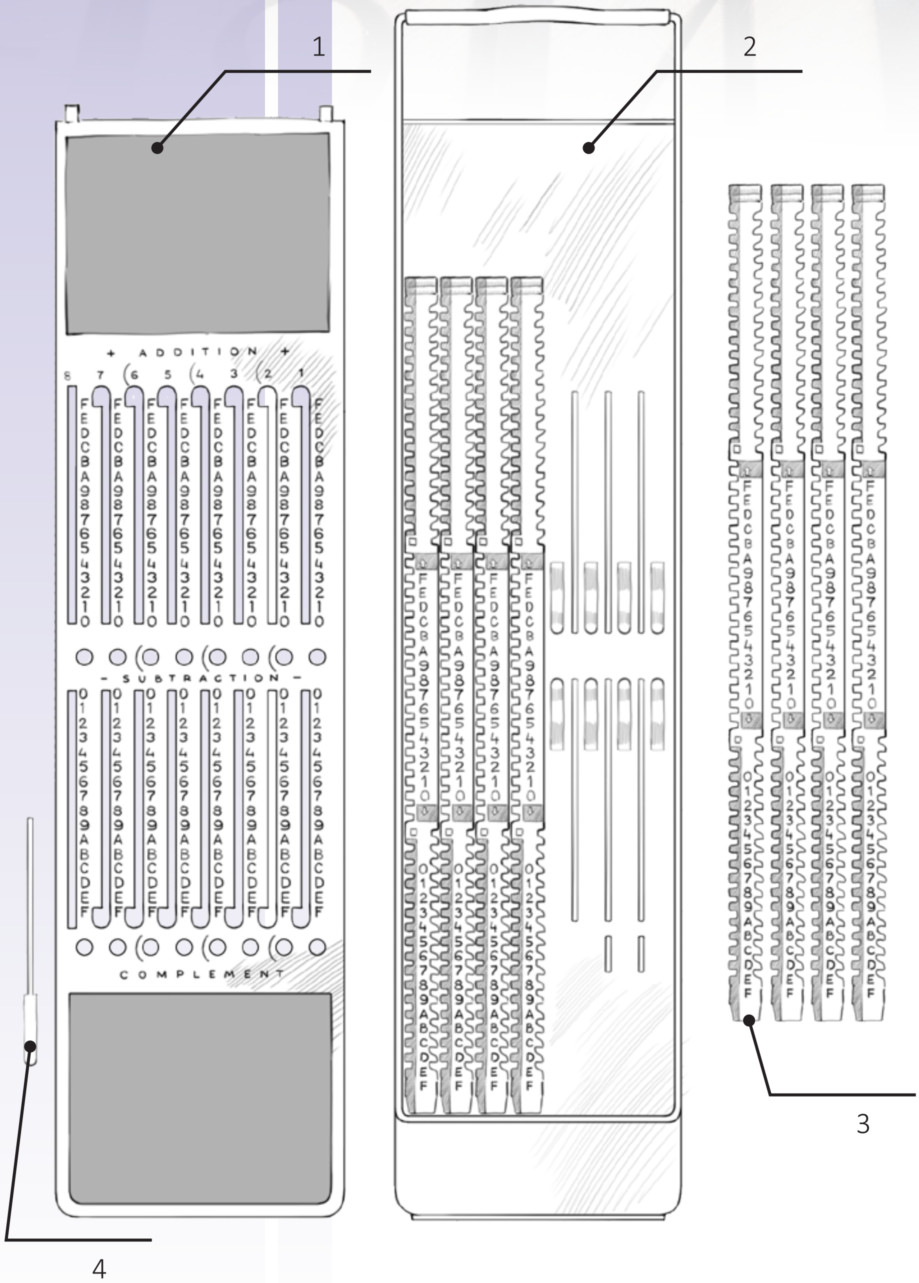
§3.1

Mechanical Addiator. What kind of mechanism is this? Where is it used?



Kummer's Addiator Structure

As we learned above, the prototype of Ugears' Mechanical Addiator was Kummer's Addiator. Let's take a closer look at it and find out how it works.

Kummer's Addiator is a structure of two connected plates "1" and "2", with several toothed racks "3" with symbols from 0 to 9 printed on them (see Fig.). Racks "3" are set inside plates "1" and "2" and can move independently of each other. Front plate "1" has holes for outputting the results of arithmetic operations, as well as slots for shifting the toothed racks using pin "4" when entering data into the addiator.

Using the addiator, you can easily perform addition and subtraction operations. Margin overflow is performed semi-automatically according to the principle "subtract 10 – x, transfer 1". Multiplication is implemented as multiple additions. There are also sophisticated algorithms for division.

§4.1

Mechanics and arithmetic process of the Mechanical Addiator STEM-model

Ugears' Mechanical Addiator is a wooden puzzle you can assemble with your own hands and study to see how the famous Kummer's Addiator mechanism works.

Let's cut to the chase—how exactly can we calculate using this device.

The addition operation of the addiator is performed by the upper scale as follows:

1. First, the addiator must be reset, so that all results windows show "0".

2. Next, enter the first addend using the stylus, that is, input the first number using the slots on the racks that correspond to the lower and higher digits of the number, and move the racks all the way down.

3. Then, input the next addend. If, when summing values, the sum of two numbers in one of the digits is no greater than "9", then entering the value of this digit of the second addend will be similar to entering the value of the first addend. However, where the sum is greater than "9", the input process for the second addend is slightly different. In that case, when entering the digit for the second addend you would shift the rack all the way down, until the ↑ symbol appears, then shift back up. The margin overflow ("1") is moved to the column on the left by moving the pin along the bend of the groove at the top of the addiator.

4.After entering the second addend, the result can be seen in the windows.

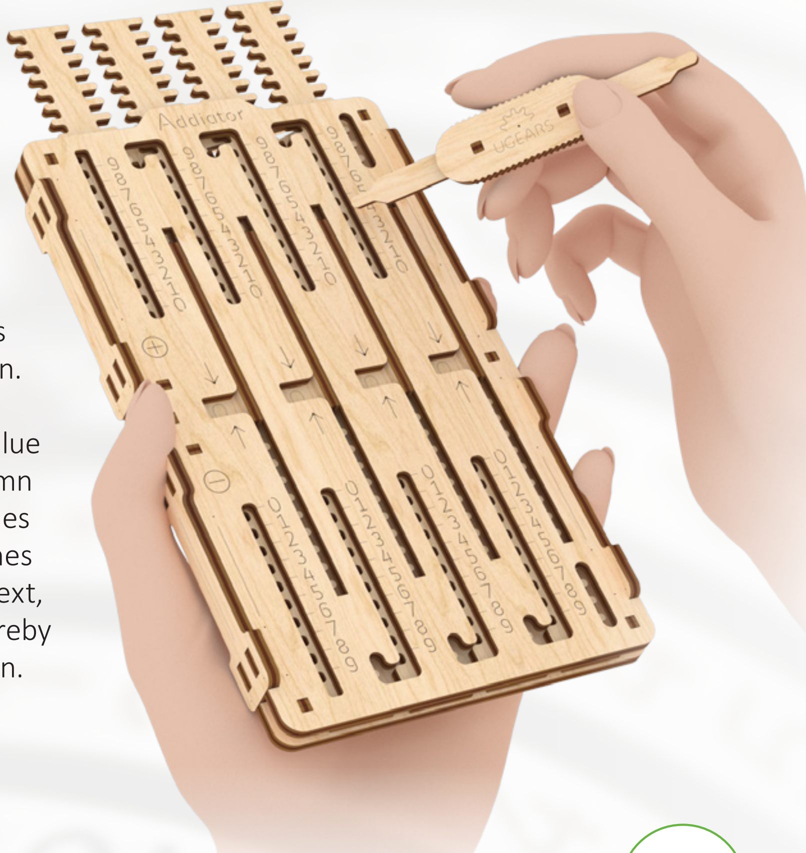
Example: 7 + 14.

The operation is performed in several stages (Fig. 4).

Reset the addiator to “0” (all windows). Enter “7” on the scale, that is, insert the stylus in the ones or digits column digit near “7” and move the rack all the way down.

Next enter “14” on the upper scale. First, input the value for the tens column by placing the stylus in the tens column near “1” and moving the rack down. Then, input the ones (or digits) value by inserting the stylus at “4” in the ones column and moving the rack down until ↑ appears. Next, move the stylus all the way up and across the bend, thereby transferring the overflow value of “1” to the tens column.

The sum that appears in your windows is 21.



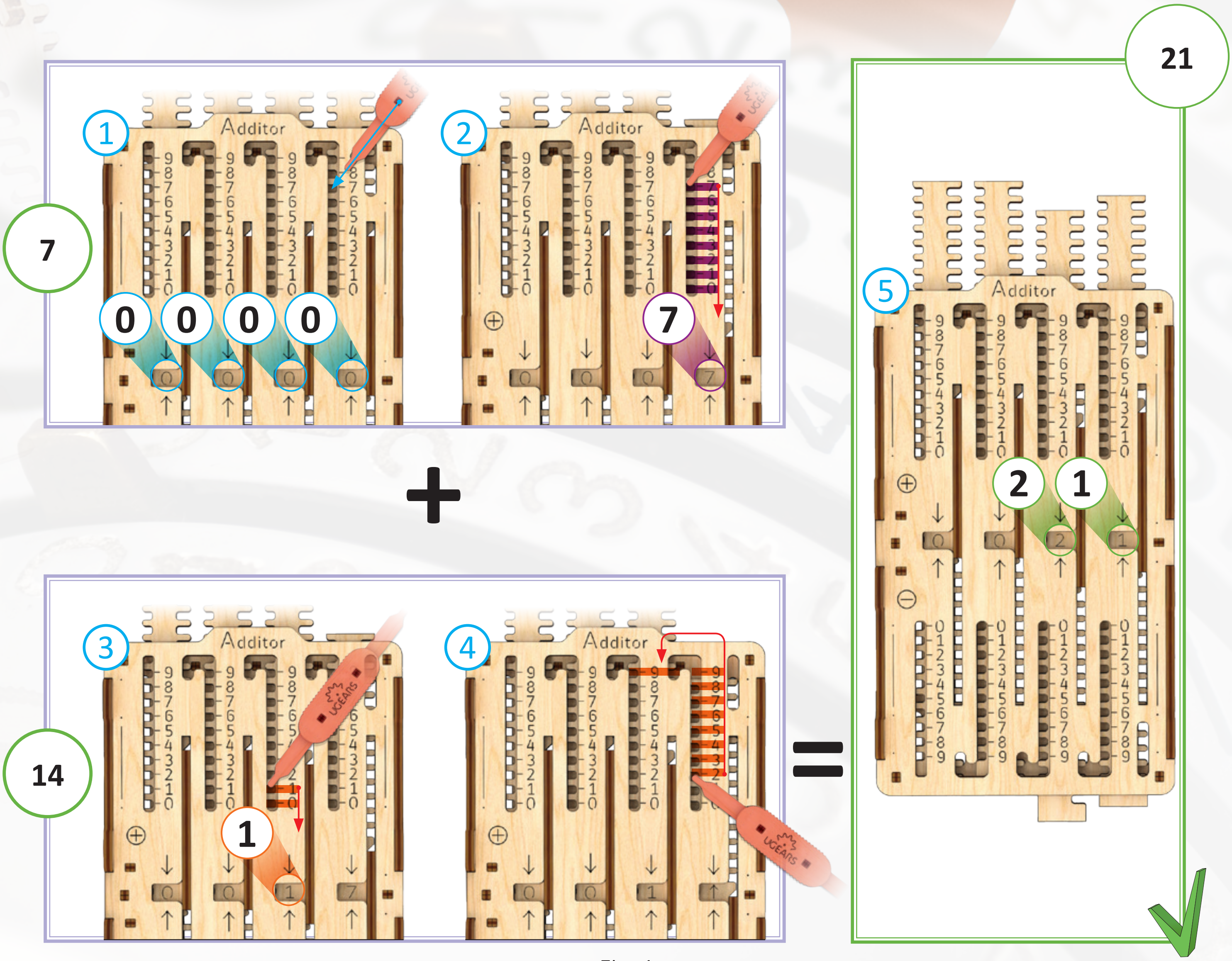
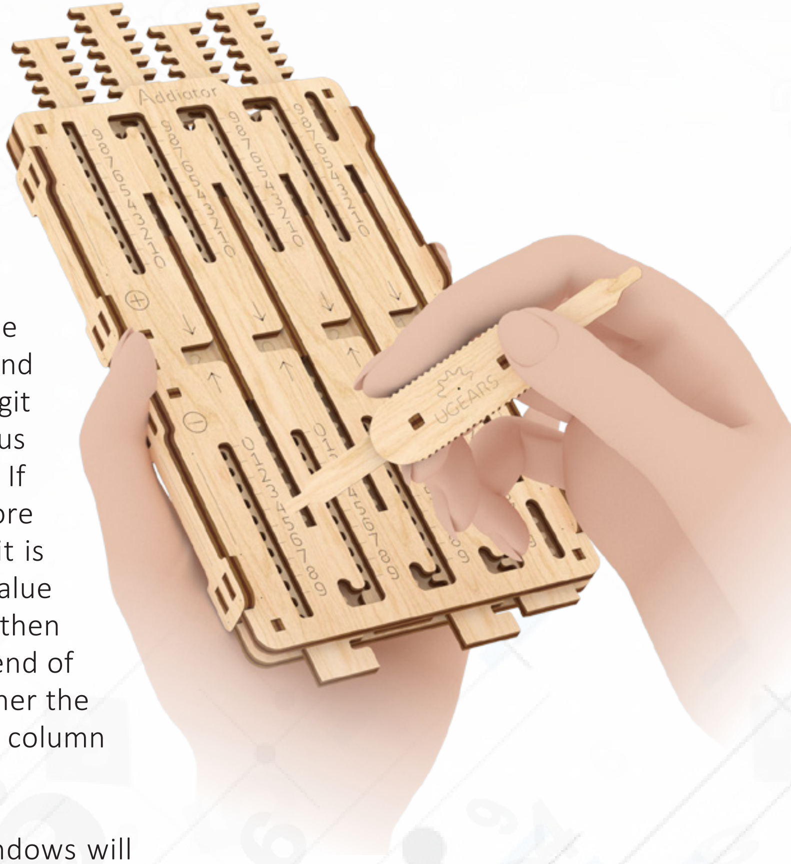


Fig. 1

The subtraction operation with the addiator is performed on the lower scale as follows:



1. First, the addiator must be reset. The values in all results windows must be “0”.

2. Next, enter the minuend (a quantity or number from which another is to be subtracted) on the upper scale of the addiator using the stylus.

3. Then, enter the subtrahend (a quantity or number to be subtracted from another) on the lower scale of the addiator. If the value of a particular digit of the subtrahend is less than or equal to the value of the corresponding digit of the minuend, the digit is entered by placing the stylus next to the subtrahend value and shifting the rack up. If the value of one of the digits of the subtrahend is more than the value in the addiator window, then this digit is entered by placing the stylus next to the subtrahend value and shifting the rack up, until the ↓ symbol appears, then shifting back down again, moving the pin along the bend of the groove at the bottom of the addiator. In this manner the margin overflow “1” is moved to (subtracted from) the column to the left.

4. After the subtrahend is entered the display windows will show the difference.

Example: 2021-1846

The operation is performed in several stages (Fig. 2).

Reset the addiator. Enter 2021 in the upper field. Now begin the entry process for the subtrahend in the lower field. The value “1” is first entered in the thousands column by inserting the stylus at “1” and moving all the way up. Next subtract in the hundreds column by inserting the stylus at “8” in the lower field, and moving it all the way up, until ↓ appears. Then move the stylus all the way down and along the bend, thereby subtracting the overflow value “1” from the thousands column to the left. Similarly, subtract “4” in the tens column, and “6” in the ones (or digits) column in turn.

The difference is 175.

Using the addiator, you can also perform multiplication and division by carrying out multiple addition and subtraction operations in sequence.

2021 - 1846 = 175

1000+800+40+6

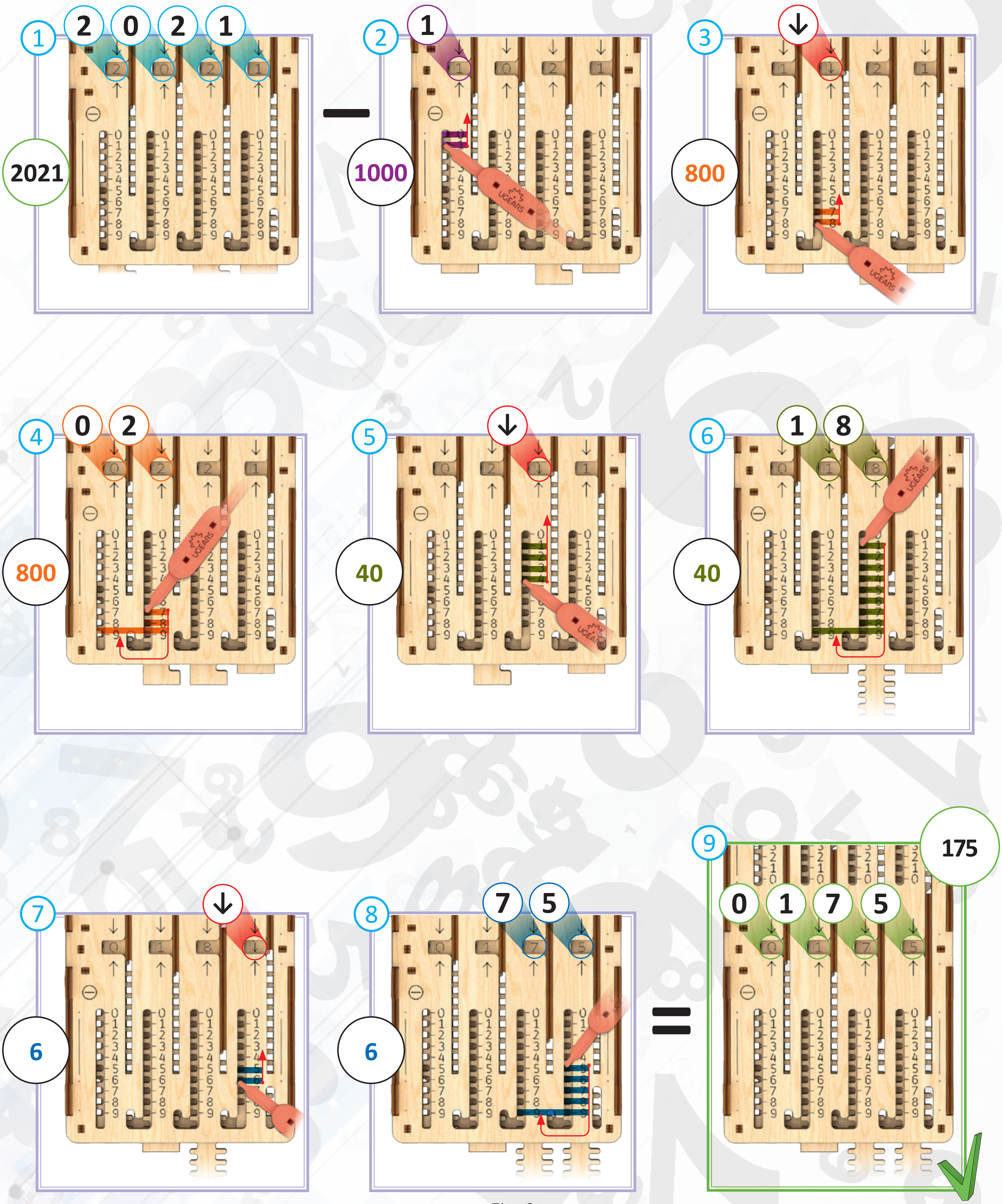


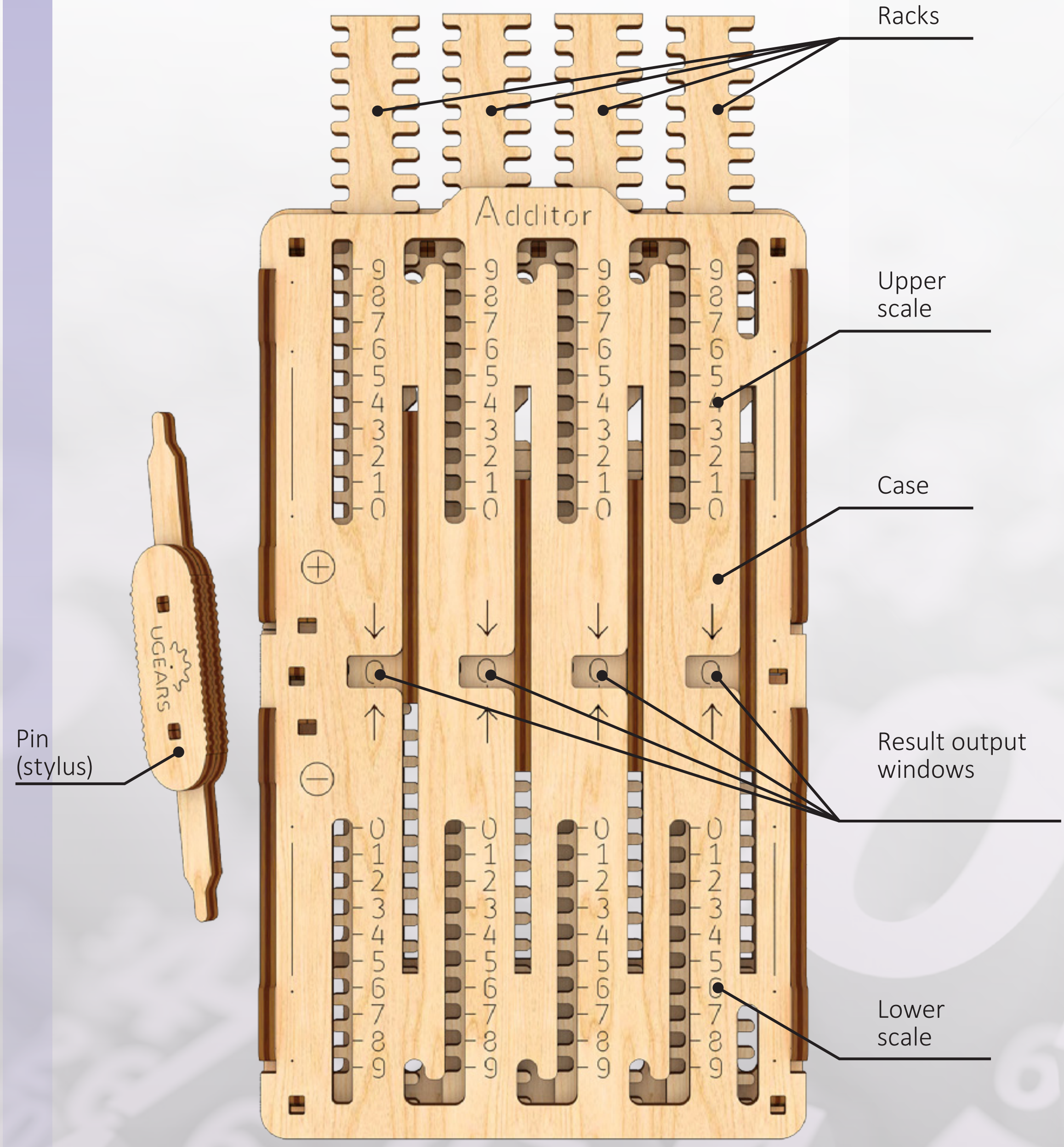
Fig. 2

§5.1

How the mechanism works

The Mechanical Addiator developed by Ugears differs from Kummer's Addiator by having a more compact design in which there is only one row of windows for outputting operation results.

Ugears Mechanical Addiator allows one to perform arithmetic operations and output the results of these operations for numbers with a maximum of four digits since it has only four racks.



Ugears Mechanical Addiator puzzle:
1 - case, 2 - racks, 3 - result windows, 4 - stylus

Our addiator is divided into two scales: upper and lower. The upper scale is used to enter the first number and perform addition, the lower scale is used to perform subtraction. The arithmetic calculations are done according to the same principles of operation as most existing addiators. The ↓ and ↑ symbols on the racks remind you to carry margin overflow to the column to the left, and even allow you to obtain calculation results with a minus sign.

Let's carry out a more complex calculation using the Mechanical Addiator model from the Ugears STEM Lab collection.
The calculation to be performed is as follows:
{(1978 – 1883) · 2 + 20} / 20

The calculation is performed in several stages.

1. Reset the addiator.
2. The first arithmetic operation is the subtraction of numbers in parentheses: 1,978 – 1,883. Enter 1,978 using the upper scale (Fig. 3a). Next, subtract 1,883 from it using the lower scale (Fig. 3b). In the ones, hundreds, and thousands columns, the value of the minuend is more than or equal to the values of the subtrahend in the same digits:

- in the ones column, 8 > 3.
- in the hundreds column, 9 > 8.
- in the thousands column, 1 = 1.

Therefore, to perform subtraction for these digits, we simply insert the stylus at the correct subtrahend digits and shift the racks all the way up. In the tens column, the value of the minuend is less than the value of the subtrahend: 7 < 8. Therefore, to perform subtraction for this digit, we insert the stylus at the "8" and move the rack up until the ↓ symbol appears in the window, then reverse direction, shifting the rack down and moving the stylus through the curved groove at the bottom, which carries the margin overflow to the digit to the left (hundreds column).

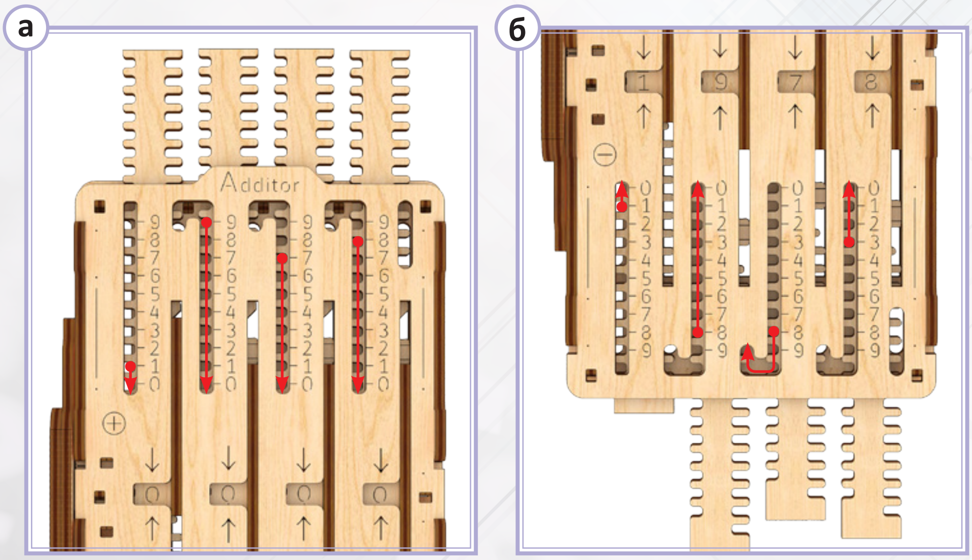


Fig. 3 Subtraction operation: a) entering the minuend (1,978), b) entering the subtrahend (1,883)

3. Next, take the result obtained in the previous operation (95) and multiply by 2. But let's replace multiplication with addition. Thus:

95x2 = 95 + 95.

Perform the addition (see Fig. 4). Enter "95" using the upper scale of the addiator. Then, add the second number by entering "5" (Fig. 4a) in the ones column, moving the rack all the way down until the ↑ sign appears in the window (Fig. 4b), then pushing the rack up and moving the stylus through the curved groove at top. We do this because the starting value "5" in the result output window + the entered value of "5" will be greater than "9". As a result, we carry the overflow value of "1" from the ones column to the tens column. The ones column now shows "0" and the display window for the tens column has shifted from "9" to the ↑ sign. We therefore need to carry the overflow value of "1" to the hundreds column by moving the stylus up and over the curve, which also resets the tens output window to "0" and carries the overflow to the column to the left. We now read "100" in the output windows (Fig. 4c).

At this point we've only added 5 to 95. We still need to add the 90 (tens column of the second addend)! Enter "9" in the tens column by inserting the stylus and pulling the rack down (Fig. 4c).

Multiplication result: 190

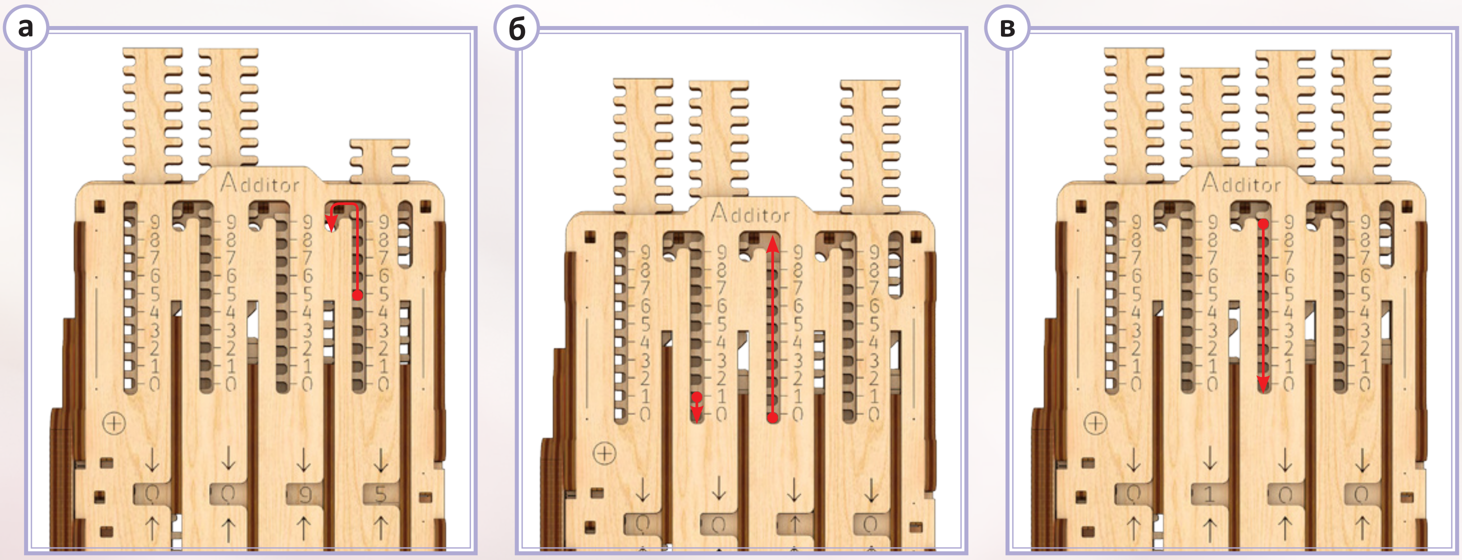


Fig. 4 Operation of multiplication by addition:
a) entering the value of the first digit of number "95", b) margin overflow, c) entering the value of the second digit of number "95"

4.The next operation is addition of 190 and 20. In the second digit or tens column of these two numbers, the sum of the values will be greater than "9" (9 + 2 = 11> 9) so we insert the stylus at "2", push all the way down, then pull the rack up, moving the stylus across the groove at the top (Fig. 5a).

Addition result: 210 (Fig. 5b)

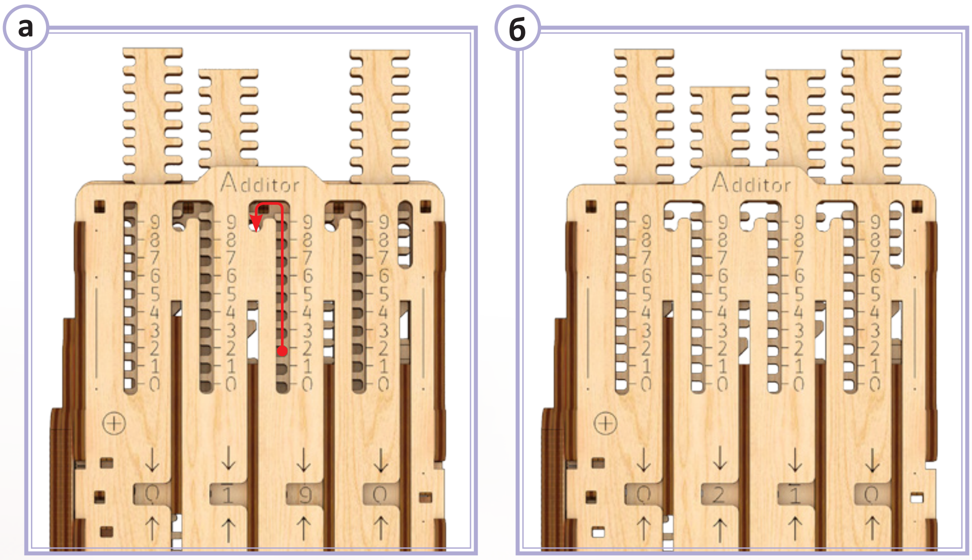


Fig. 5 Addition operation: a) entering the value of the second digit of number “20”, b) addition result

5.The final operation is division. We will replace division by subtracting “20” from “210” until the remainder appears, while counting the number of subtractions performed.

After performing 10 subtraction operations, we obtain a remainder of 10 (see Fig.).

Fig. Remainder at the end of division by subtraction

6.The approximate result of calculating:

{(1978 – 1883) · 2 + 20} / 20 ≈ 10 (because we performed 10 subtraction operations).

If we consider the remainder (10) is half (.5) of the divisor (20), then we can obtain the exact result: 10.5 (10 complete subtraction operations completed, plus a remainder that is .5 of the divisor).

After calculating the expression using a calculator, we obtain the same result: 10.5

§3.2

Mechanical Multiplier What kind of mechanism is this? Where is it used?

The Mechanical Multiplier is a lever mechanism, driven by two sliders, which, when moved, change the position of the output window, which is a pointer that moves along the field of the multiplication table. The device allows multiplication of two integers from 1 to 12.

The position of the first slider corresponds to the smaller of the two multipliers, while the position of the second slider corresponds to the larger of the two multipliers. Because the pantograph mechanism provides rectilinear movement, the output window takes an unambiguous position.

The Mechanical Multiplier allows you to multiply numbers from 1 to 12, as well as square numbers.

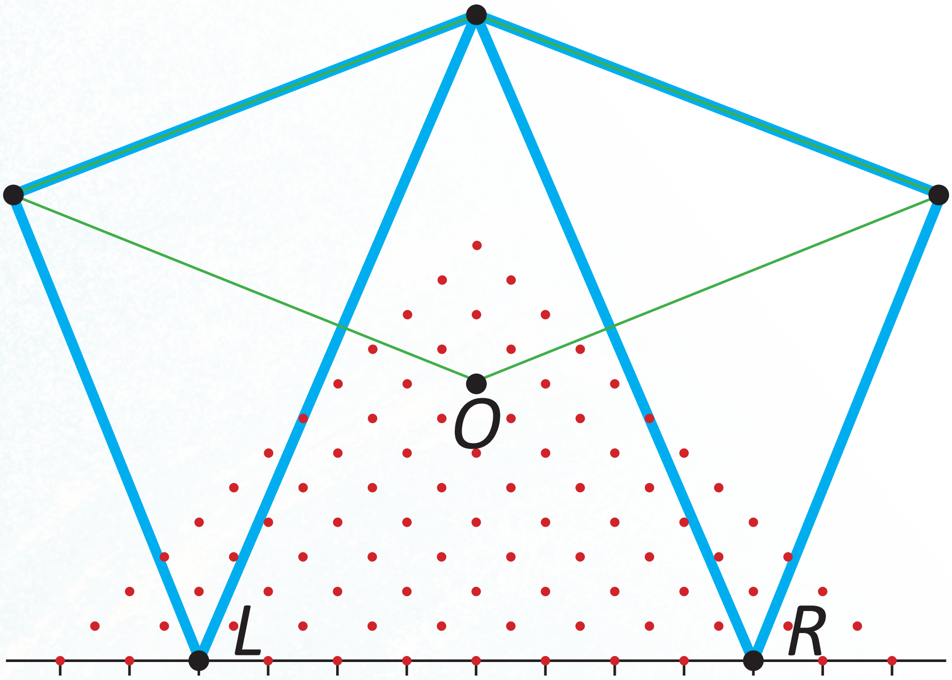
·	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
3	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
4	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
5	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
6	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120
7	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140
8	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120	128	136	144	152	160
9	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135	144	153	162	171	180
10	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
11	11	22	33	44	55	66	77	88	99	110	121	132	143	154	165	176	187	198	209	220
12	12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240
13	13	26	39	52	65	78	91	104	117	130	143	156	169	182	195	208	221	234	247	260
14	14	28	42	56	70	84	98	112	126	140	154	168	182	196	210	224	238	252	266	280
15	15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300
16	16	32	48	64	80	96	112	128	144	160	176	192	208	224	240	256	272	288	304	320
17	17	34	51	68	85	102	119	136	153	170	187	204	221	238	255	272	289	306	323	340
18	18	36	54	72	90	108	126	144	162	180	198	216	234	252	270	288	306	324	342	360
19	19	38	57	76	95	114	133	152	171	190	209	228	247	266	285	304	323	342	361	380
20	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400

The multiplication table (or times table) is a table in which rows and columns are assigned sequential integers, and the cells contain the result of multiplying these integers. The table is used for learning multiplication. School children learn such tables by heart.

§4.2

Mechanics and arithmetic process of the Mechanical Multiplier STEM-model

As we said earlier, the Ugears Mechanical Multiplier is designed like Consul the Educated Monkey. The basis of the mechanism is two identical isosceles right-angled triangles, connected by a hinge, with the ends of their hypotenuses resting on a number line along which they can slide, thereby choosing numbers to multiply.



The legs of the isosceles triangles are also connected by a hinge, making them easy to move.

The vertices of the triangles are also connected by a hinge mechanism to each other.

Isosceles triangles provide a linear dependence of the height of the connection point of the vertices of the triangles above the number line to the length of the segment between two values of the number line. The height is always equal to half the specified length.

Since the values on the number line are evenly located, then at all possible positions of the ends of the triangles, they will form a triangle of values (plotted values) with the connection point of the vertices of the isosceles triangles. The rows of the triangle of values are at the same height from each other. The plotted positions within each row are horizontally located at the midpoint between plotted positions in adjacent rows.

Thus, the Mechanical Multiplier implements a binary operation; that is, each position of the variables sets a unique position of the output window, where the result of the operation appears.

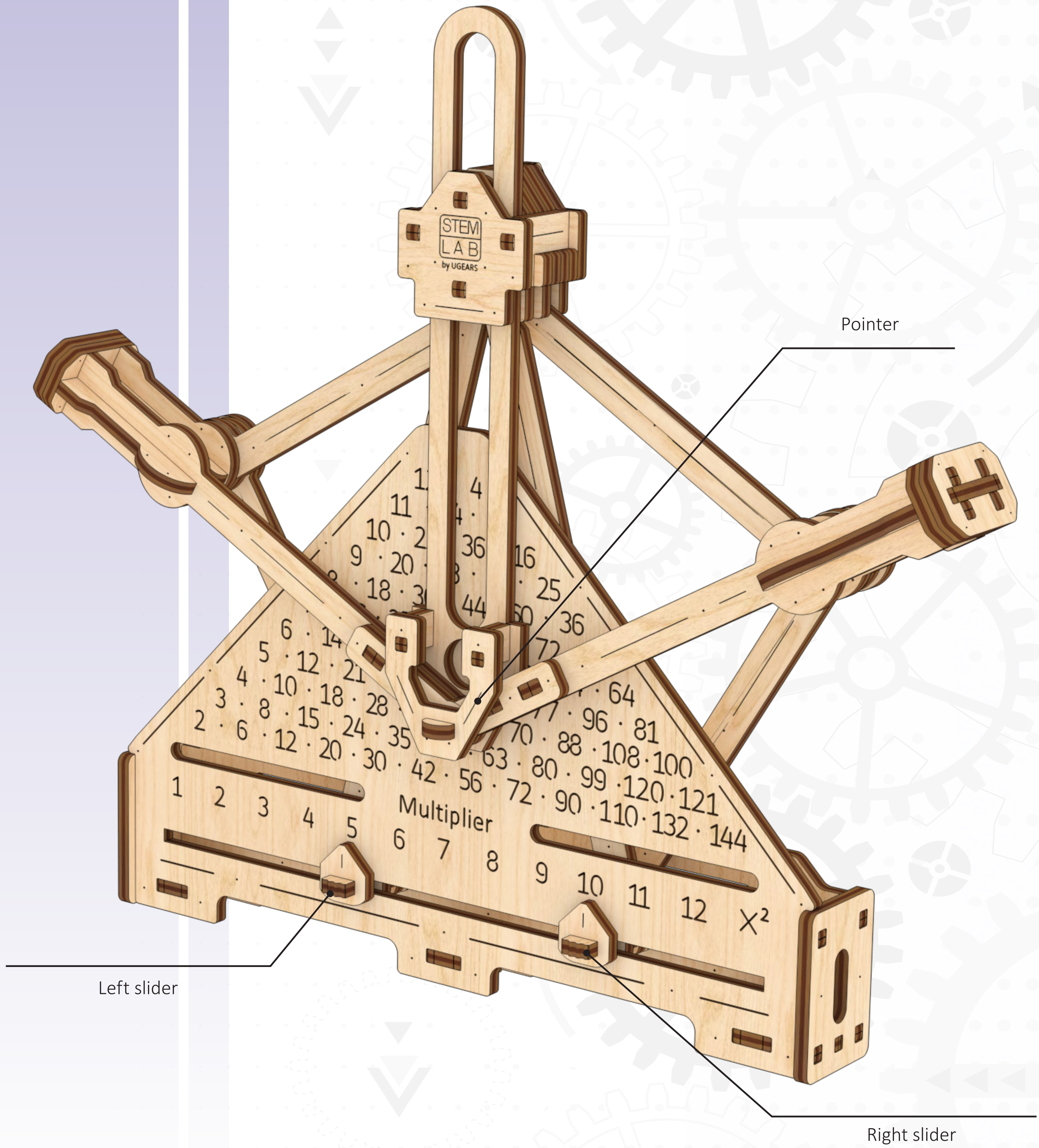
In order to multiply two identical numbers, i.e., to get the square of a number, a special additional position (x^2) has been added to the right of the number line, and the triangle of values supplemented with the corresponding numbers: the squares of numbers 1-12, to which the indicator (output window) will point.

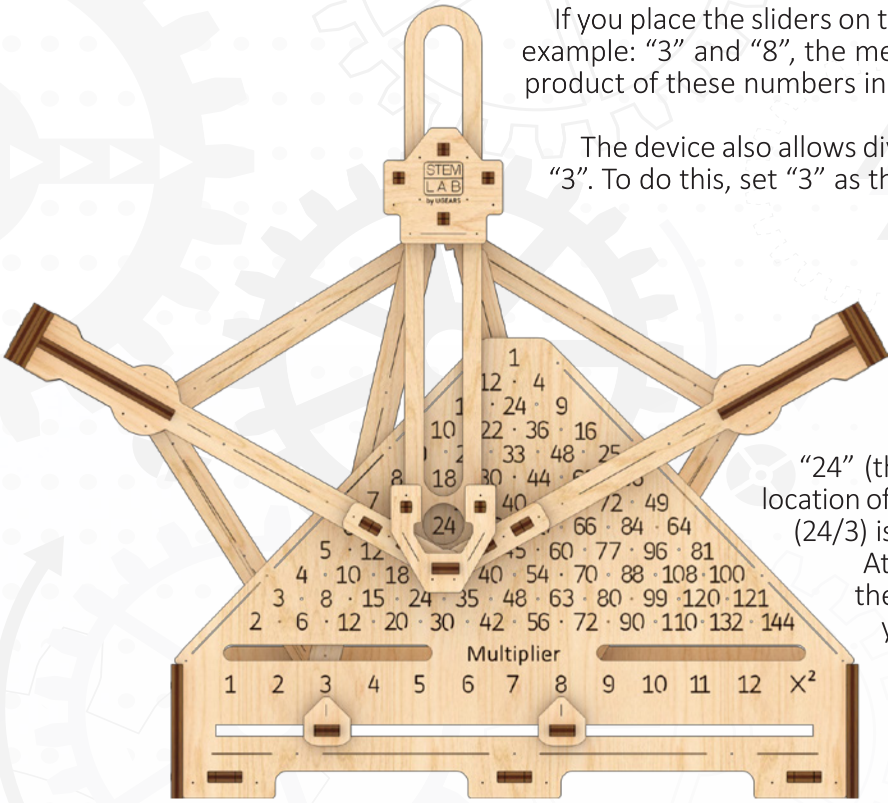
* Binary operation (lat. "Bi" - "two"): a mathematical operation, such as addition or multiplication, performed on two elements of a set, to derive a third element.

§5.2 How the mechanism works

The Mechanical Multiplier puzzle consists of the main frame, hinges, an indicator plank, and sliders. A table with values (calculation results) is applied to the model's frame, beneath which the integers 1-12 are plotted (initial data).

The device is controlled by two sliders: right and left. The sliders are hinged to the pointer through a lever system.





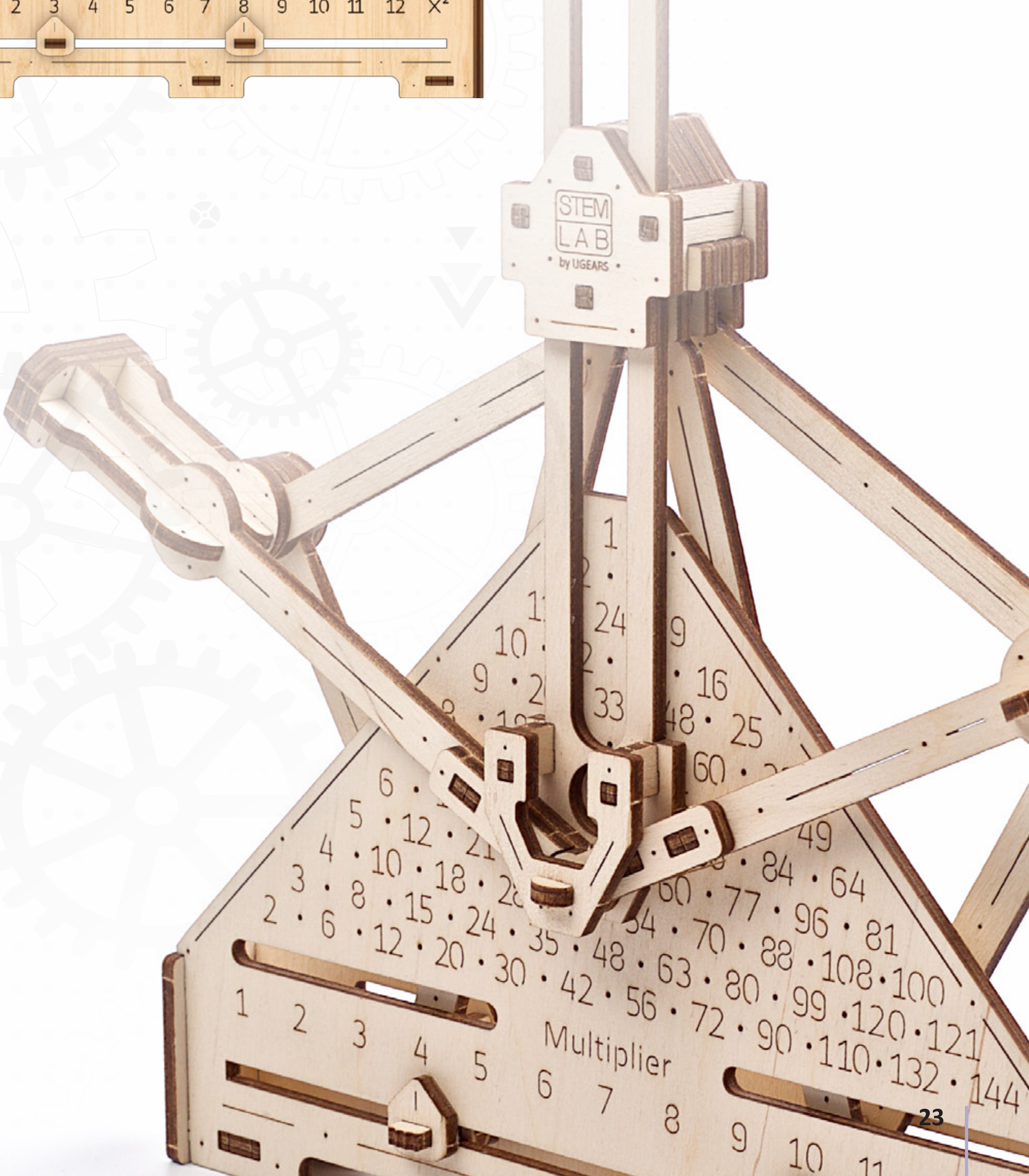
If you place the sliders on two numbers in the range from “1” to “12”, for example: “3” and “8”, the mechanism will move the pointer and show the product of these numbers in the output window.

The device also allows division. For example, we need to divide “24” by “3”. To do this, set “3” as the divisor, using the first slider.

Keep the first slider stationary on “3” while moving the second slider along the number line. As you do so, notice the various results in the output window, indicating which numbers are divisible by “3”.

When the output window arrives at the value “24” (the dividend in our math problem) notice the location of the second slider, which shows us the quotient (24/3) is 8.

At the extreme right position of the right slider is the special additional position (x^2), which allows you to find the square of the number indicated by the left slider.



§6

Laboratory work

Task 1. Perform calculations using the Mechanical Addiator:
(15+45) / 3 =
(145+8) - 17 =
(200-196) + 43=

Task 2. Pick two numbers from “1” to “12” at random. Multiply them in your mind. Then verify your answer with the Mechanical Multiplier.

Task 3. Divide “45” by “5” using the Mechanical Multiplier, according to the method specified in paragraph five.

Task 4. Square “7” using the Arithmetic Kit. Choose whichever device you prefer.

TEST

1. Kummer’s Addiator is:
☐ a) the first computer
☐ b) a compact computing device
☐ c) a multiplication device/computing tool

2. Which scientist gave his name to the rules for performing arithmetic operations?
☐ a) Leonardo da Vinci
☐ b) Mohammad ibn Musa al-Khwarizmi
☐ C) Blaise Pascal

3.A punched card is:
☐ a) a data storage media
☐ b) a computing device
☐ c) a movable rack in Kummer’s Addiator

4. The first American computer was:
☐ a) Mark 1
☐ b) Pentium
☐ c) Celeron

5. What is/are the mechanism(s) behind Ugears Arithmetic Kit?
☐ a) Kummer’s Addiator
☐ b) Consul the Educated Monkey toy
☐ c) the Pascaline machine

Congratulations! You made it!

Thank you for being with us in this adventure, we hope you had fun and learned a thing or two!

Correct answers: 1.b, 2.b, 3.a, 4.a, 5.a and b.