DES 111 INTRODUCTION TO PRODUCT DESIGN

END TERM PROJECT REPORT

VERTICAL ABACUS

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BACKGROUND

History:

The word Abacus has been derived from a Greek word ‘abax’ or ‘abakon’ which means ‘tabular form’ that is possibly derived from a Semitic word ‘abq’ which means ‘sand’.

Invention of Abacus-

The abacus is the most primitive form of calculating device which was invented somewhere in between 300-500 BC. The abacus has travelled a long way and had transitions as it travelled in different countries over the world.

How did it work?

The abacus in ancient days was used purely as a calculating device. Every bead was assigned a value starting from a units place moving towards the left. The beads in the upper deck had different values than of those in the lower deck. The calculating process necessitated the use of both hands of the person using it. All the calculations were based on the movements of the beads. This was probably one of the greatest invention of the ancient days that helped the merchants and traders in their accounting.

How Abacus Came Into Existence?

The necessity

There was a time when there were only 9 (1 to 9) digits available for counting purposes that too on fingers. This made it difficult for the traders to calculate the cost of selling and purchase of goods. That was the time when the abacus instrument was made for long additions, subtractions, multiplications, divisions, negative numbers etc.

It was earlier structured horizontally having a wooden frame and beads of stones and pebbles which were later changed to vertical alignment. Over the years it has been transformed several times and is now finally used as a brain development tool for small kids.

Who Invented Abacus?

Abacus was invented by Chinese in 500 BC (while some indications argue on its invention by Babylonians in 300 BC) and was used as one of the most primitive calculators (or counting device to be precise). The first century sources have also given evidence on abacus being used by Indians with a separate column that counted digits with 'shunya' (zero). Although, the history still searches for facts that can give a confirmed statement on the invention of abacus.

The Salamis tablet (300 BC) used by Babylonians circa is considered to be the ancestor of abaci. Then came the Roman and Greek abaci, which had different orientation and presentation, but same functionality. Different ages brought different changes in the forms of abaci as its usage was adapted by races from China, India, Korea, Persia, Rome, Japan and Russia.

The Suanpan, one of the modern age abaci which was a Chinese abacus had 2/5 decks and due to its complexity was replaced by Soroban abacus, a Japanese abacus, which was developed further by a famous mathematician Seki Kowa who removed one bead each from upper and lower decks to make it 1/4 decks.

What is the difference between a counting board and an abacus?

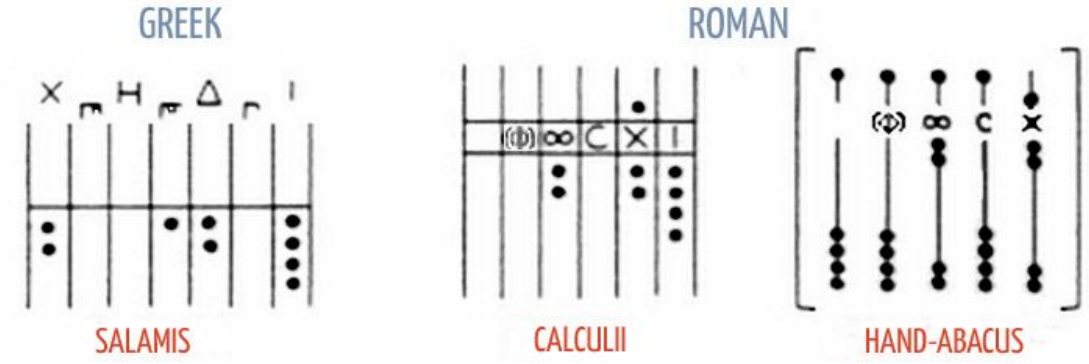
It is important to distinguish the early abacuses (or abaci) known as counting boards from the modern abaci. The counting board is a piece of wood, stone or metal with carved grooves or painted lines between which beads, pebbles or metal discs were moved. The abacus is a device, usually of wood (romans made them out of metal and they are made of plastic in modern times), having a frame that holds rods with freely-sliding beads mounted on them. Both the abacus and the counting board are mechanical aids used for counting; they are not calculators in the sense we use the word today. The person operating the abacus performs calculations in their head and uses the abacus as a physical aid to keep track of the sums, the carries, etc.

What did the first counting board look like?

The earliest counting boards are forever lost because they were constructed of perishable materials like wood. Educated guesses can be made about the construction of counting boards based on early writings of Plutarch and others.

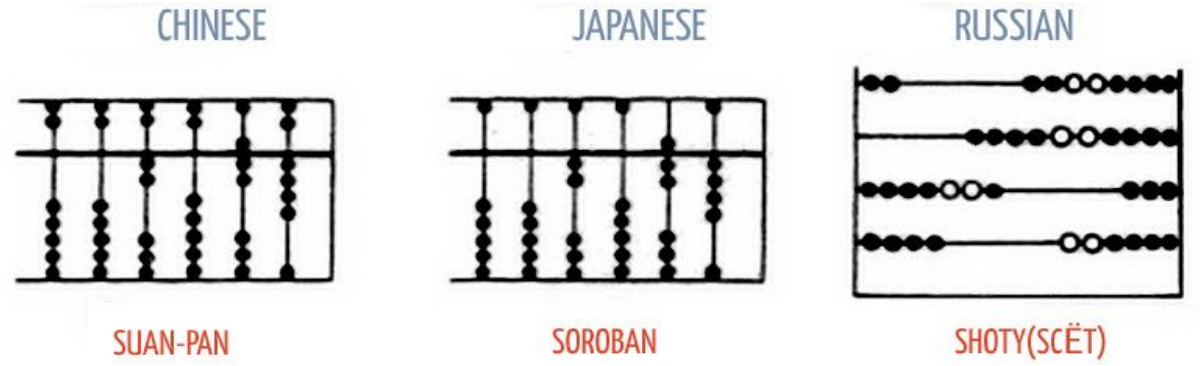
Used in outdoor markets of those times, the simplest counting board involved drawing lines in the sand with one's fingers or with a stylus, and placing pebbles between those lines as place-holders representing numbers (the spaces between the lines would represent the units 10s, 100s, etc.); two pebbles in the 10s column would indicate 20. Affluent merchants could afford small wooden tables having raised borders that were filled with sand (usually coloured blue or green). A benefit of these counting boards on tables, was that they could be moved without disturbing the calculation— the table could be picked up and carried indoors.

With the need for portable devices, wooden boards with grooves carved into the surface were then created and wooden markers (small discs) were used as place-holders. The wooden boards then gave way to even more more durable materials like marble and metal (bronze) used with stone or metal markers.



Ancient Times

Middle Ages



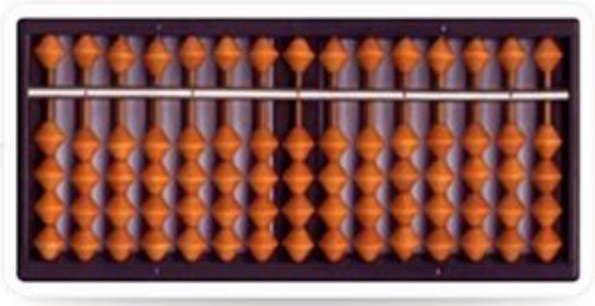
Modern Times

STUDY

Abacus Today

The abacus we use today is the Soroban abacus. It gained popularity with the whole World competing on a common platform after Globalization. It had an impact on the education system of different nations The abacus is still in use today by shopkeepers in Asia and "Chinatowns" in North America. The abacus is still taught in Asian schools, and a few schools in the West. Blind children are taught to use the abacus where their sighted counterparts would be taught to use paper and pencil to perform calculations.

One particular use for the abacus is teaching children simple mathematics and especially multiplication; the abacus is an excellent substitute for rote memorization of multiplication tables, a particularly detestable task for young children. The abacus is also an excellent tool for teaching other base numbering systems since it easily adapts itself to any base.



Functions Of Abacus

An abacus instrument allows performing basic operations like Addition, Subtraction, Multiplication and Division. It can also carry out operations such as counting up to

decimal places, calculates sums having negative numbers etc.

Construction Of Abacus

A suanpan (top) and a soroban (bottom). The two abaci seen here are of standard size and have thirteen rods each.

Another variants of Soroban

The soroban is composed of an odd number of columns or rods, each having beads: one separate bead having a value of five, called go-dama ("five-bead") and four beads each having a value of one, called ichi-dama ("one-bead"). Each set of beads of each rod is divided by a bar known as a reckoning bar. The number and size of beads in each rod make a standard-sized 13-rod soroban much less bulky than a standard-sized suanpan of similar expressive power.

The number of rods in a soroban is always odd and never fewer than nine. Basic models usually have thirteen rods, but the number of rods on practical or standard models often increases to 21, 23, 27 or even 31, thus allowing calculation of more digits or representations of several different numbers at the same time. Each rod represents a digit, and a larger number of rods allows the representation of more digits, either in singular form or during operations.

The beads and rods are made of a variety of different materials. Most soroban made in Japan are made of wood and have wood, metal, rattan, or bamboo rods for the beads to slide on. The beads themselves are usually biconal (shaped like a double-cone). They are normally made of wood, although the beads of some soroban, especially those made outside Japan, can be marble, stone, or even plastic. The cost of a soroban is commensurate with the materials used in its construction.

One unique feature that sets the soroban apart from its Chinese cousin is a dot marking every third rod in a soroban. These are *unit rods* and any one of them is designated to denote the last digit of the whole number part of the calculation answer. Any number that is represented on rods to the right of this designated rod is part of the decimal part of the answer, unless the number is part of a division or multiplication calculation. Unit rods to the left of the designated one also aid in place value by denoting the groups in the number (such as thousands, millions, etc.). Suanpan usually do not have this feature.

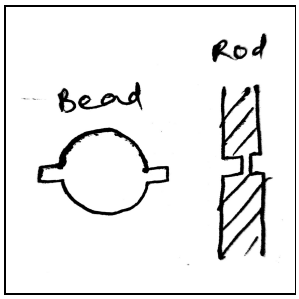
BRIEF

Normally an abacus is used horizontally because it is a tool for an individual to use. Such usage enables complex calculation at a high speed as it lies next to its user and due to being lightweight, the beads can be moved 'up' or 'down' quickly. This works well for those who are adept at using the abacus for their personal calculations. However, the normal abacus cannot be used to teach or demonstrate to larger groups as it cannot be displayed vertically. Moreover the lightweight beads, while using less energy to be moved, can easily change position with slight force, disrupting the calculation. Young children who have comparatively less dexterity and accuracy of motor control often face this problem. Therefore the normal abacus is not ideal for teaching or learning. It also poses a challenge for the visually impaired. Here a vertical abacus can be attempted to be made to solve this problems and explore new possibilities of how the device can be used.

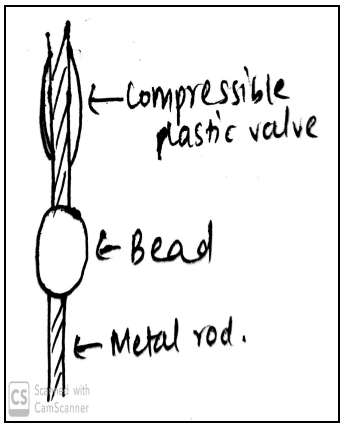
CONCEPTS

As mentioned in the brief, this project will attempt to make a fully functional vertical abacus without structurally changing how the tool works. By doing so, the aim is to eliminate the challenges that a normal abacus poses to children, demonstrators and the visually impaired.

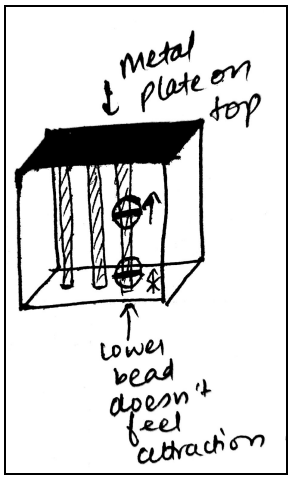
We came up with 5 different ideas for the same. They are as follows:



Concept 1: This was the first idea we came up with. The rod and bead would both be wooden in this case. We thought of making grooves on the rod while the bead would have cylindrical projections which would fit in these grooves. However we realised that this system would lack speed which is an essential characteristic of an abacus. This system wouldn't have been very durable either considering the grooves and projections would rub off repeatedly and wear off.

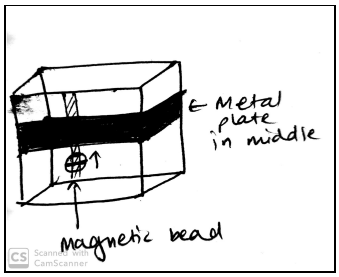


Concept 2: This was another idea where we thought of. The rod would be metallic while the beads would be wooden. The rod would have a plastic valve which would compress to allow the beads to slide upwards and downwards. This system wouldn't have been very cost effective and would increase the cost of including plastic in the system and changing it quite frequently as it changes its shape permanently.

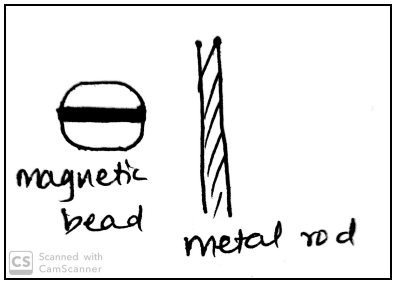


Concept 3: This was our third idea wherein we decided to have a metal sheet on the top of the cuboid. The beads would be magnetic in this case so as to get attracted to the metallic sheet. The rods will also be metallic. The rods have to be long enough to ensure that the lower beads don't get attracted to the sheet and at the same time the attracted beads don't get re-attracted by beads at the bottom. This arrangement is neither cost effective nor portable as the metal

sheet requires the whole arrangement to be larger thus costing more money and non-portable.



Concept 4: This is the fourth idea that we thought of wherein we just shifted the placement of the sheet in the arrangement. Instead of placing it at the top, we decided to place it in the middle however on more brainstorming we realised that it is neither durable nor very fast to work with hence we discarded it.



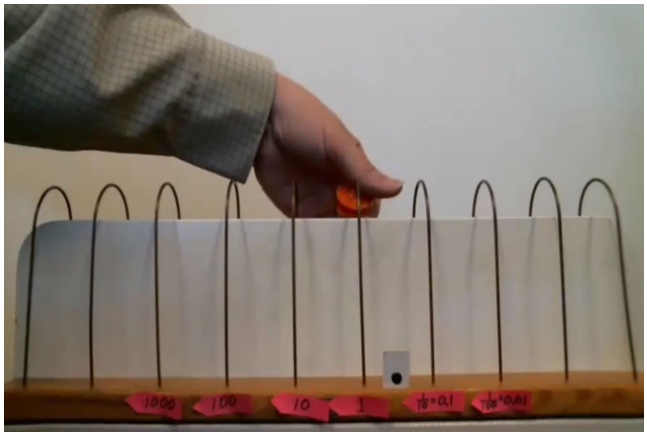
Concept 5: After days of brainstorming we came up with this idea and after evaluating it we decided to work on this as this had more pros than cons. In this arrangement we have used wooden beads with magnet at the centre and metallic rods. The entire abacus frame is of wood. This arrangement is fast to work with and speed of working is equivalent to a normal abacus. It is hassle free and can be used by children also. As the frame is of soft wood ,the system is not too heavy and can be easily carried from one place to another.

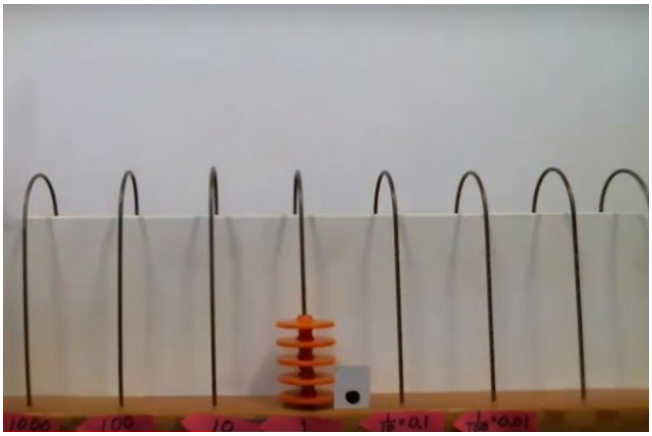
EVALUATION

We have used Pugh Concept to evaluate all our ideas and pick out the best one.

We mark each concept as (+,-,S) on different criteria for how it is compared to the already existing vertical abacus whose picture I have attached alongside.

We then sum up the +,-,S for each solution and pick out the best one.

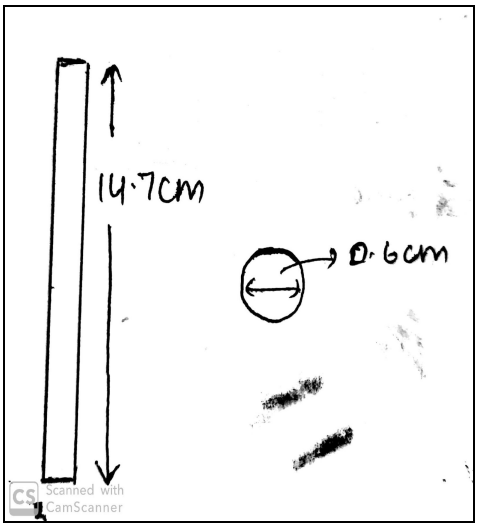




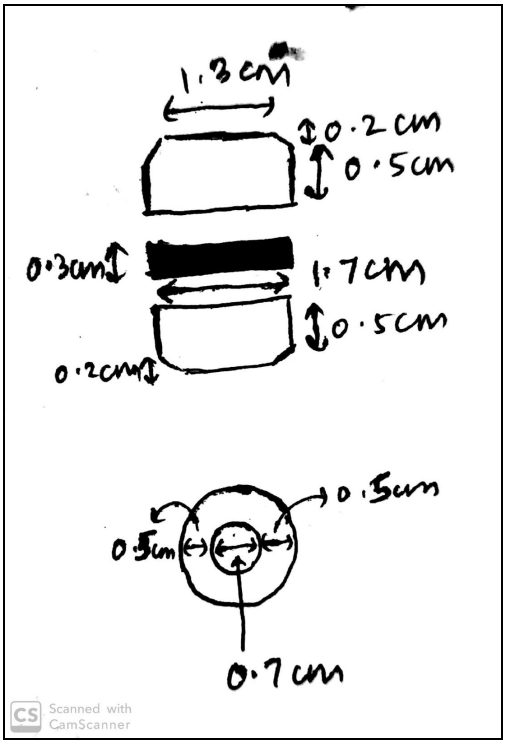
A picture of an existing vertical abacus and how the beads are transferred from one side to another is order to calculate mathematical problems

	C1: Beads and rod with grooves	C2: Plastic Valve System	C3: Metal sheet on the top	C4: Metal sheet in the middle	C5: Magnetic beads with metal rods
Speed	-	S	S	-	+
Ease of Usage	S	+	+	+	+
Ease of Manufacturing	S	S	S	S	S
Durability	-	S	S	-	S
Cost effective	S	-	-	S	S
Portability	+	+	-	+	+
Total	-1	+1	-1	0	+3

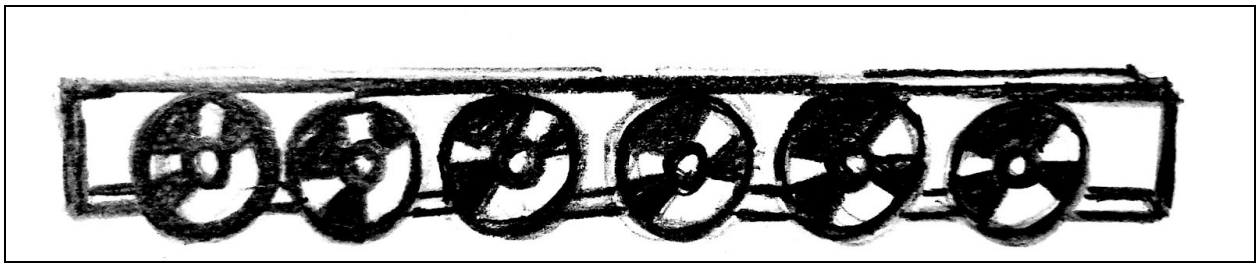
DETAILING



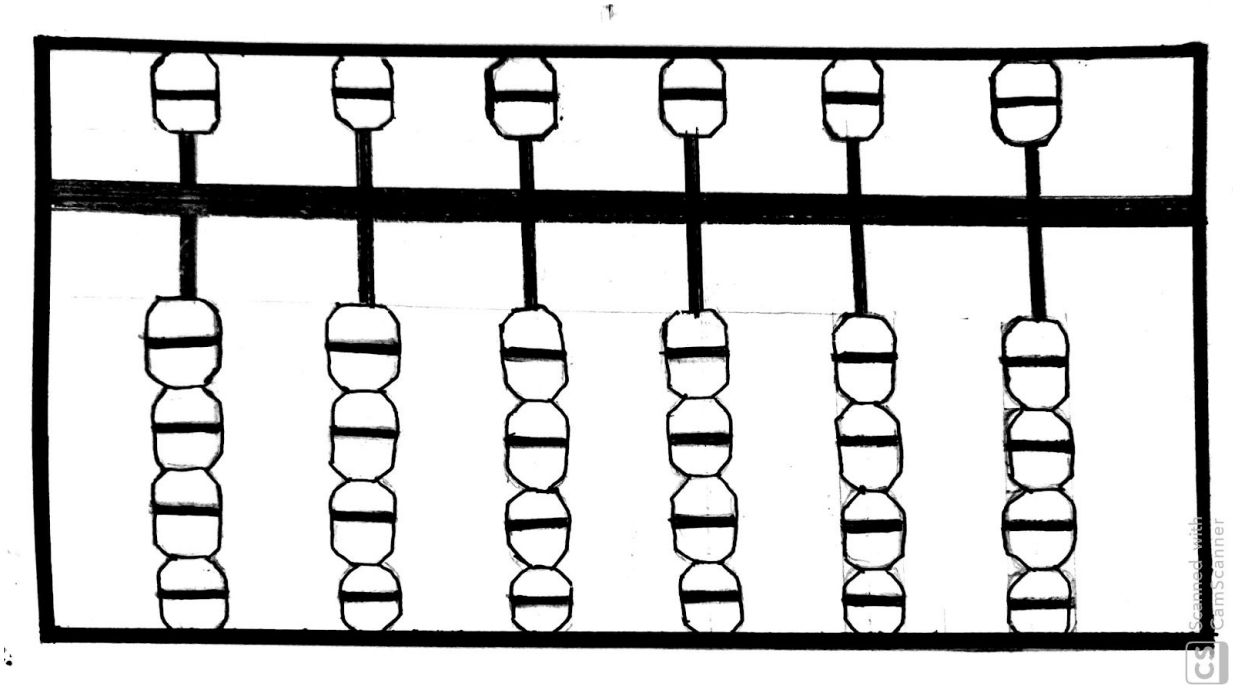
Dimensions of the metal rod



Dimensions the wooden bead and magnet



Top View of the abacus



Front view of the entire arrangement

MANUFACTURING

Materials Used:

1. The beads of the Abacus have a magnet sandwiched between the two half wooden beads of lower diameter 1.7cm, upper diameter 1.3cm and height 0.7cm(including the curvature of 0.2cm)
2. The magnet has an inner diameter of 0.7cm and an outer diameter of 1.7cm.
3. The rods on which the beads are put are metal rods. The metal rods have a diameter of 0.6cm. We have used metal rods so that the force of attraction between the rod and the magnet in the bead holds the bead in position and it doesn't slide down.
4. There is a gap of 4cm between two rods.
5. The beads are painted with acrylic paints and a contrast from a lighter shade to a darker shade is given as we progress from one rod of beads to the other.
6. The frame of the abacus is of wood and has the following dimensions:

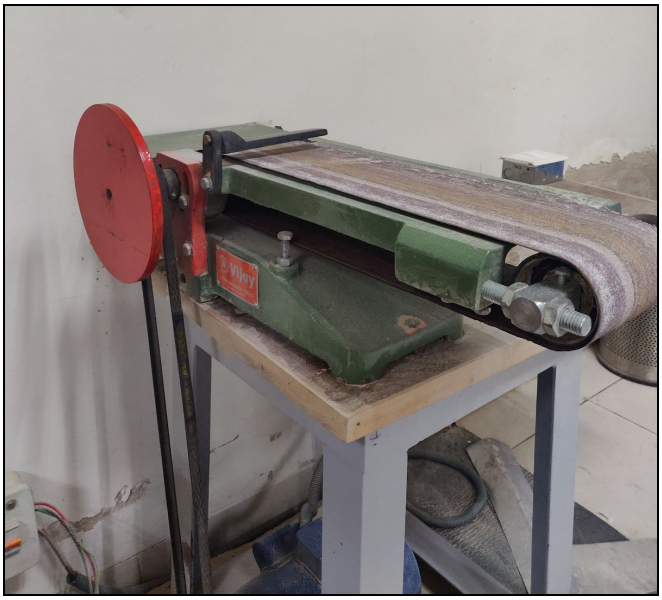
- The vertical rods are of diameter 1cm and height 13.8cm
- The horizontal blocks are of width 1.7cm, height 1.3cm and length 27.5cm.
- The rod separating the two segments is of height 0.6cm, width 1.7cm and length 24.7cm.
- The inner strip of wood is at a distance of from the top of the frame and at a distance of 3.4cm from the top and 10.7cm from the bottom.

Machines Used:

Lathe machine was used to make beads out of the wood. Firstly the wooden log was cut using the lathe machine to make it into circular log of wood of the diameter same as that of the outer diameter of the magnet. The machine constantly rotates the log of wood. A hole was made of the diameter of the inner diameter of the magnet. Two half beads were made and an octagon type of the shape was given by keeping the cutter at an angle.

The frame of the abacus required a wood cutter to cut it of the required dimensions. It also required other tools like drill machine, wood planer, sander machine.

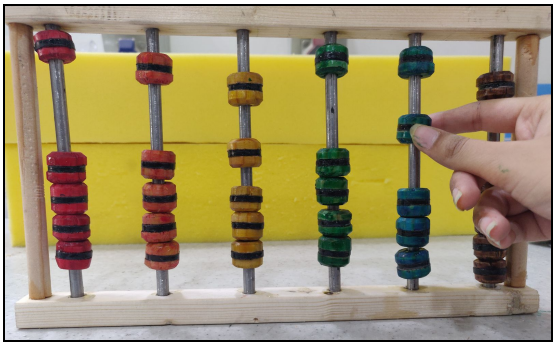
Wood Planer

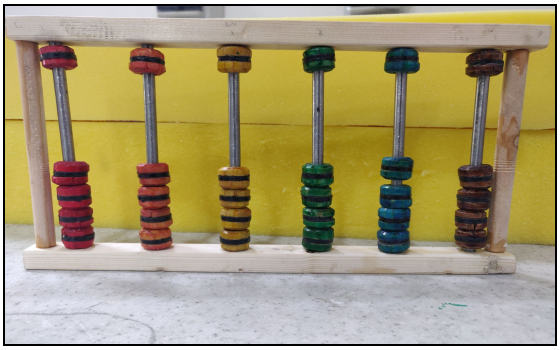


Sanding Machine

Drilling Machine

Lathe Machine





PROBABLE APPLICATIONS

1. Use of this abacus as a scoreboard while playing games with kids.
2. Can be used by kids to do basic maths calculations is a fun way to make their learning experience more interactive.
3. Can be clubbed with jigsaw puzzles and chalkboard to make them more interesting and fun.

THE END