K’Nex Ball Amusement Machine – The Pinfield

Introduction

This is an amusement machine which is made almost entirely from K’Nex. The non-K’Nex components are the balls (which are made of bouncy rubber), the signs and the column labels.

There are two slots; one is for children’s use and is low down, and the other (near the top of the machine) is for adults’ use. When a ball is inserted in the lower slot, a chain hoist raises it to the level of the higher slot – it's powered by a 12-volt K'Nex motor.

Each inserted ball runs down a channel near the top of the machine and bounces down an array of pins. It then lands in one of 14 columns.

Each column can hold up to seven balls. A full column is indicated by a pink flag (in the picture on the left, columns 4, 9 and 10 are full). When an eighth ball enters a column, the seven balls are released into a winnings tray. The winning ball ends up in a box at the base of the machine.

If one of the three columns at the far left or far right of the machine is filled, all three columns get emptied into the tray.

There are some ‘blockers’ between some of the pins so that the balls end up fairly evenly distributed through columns 4 to 11. The three columns at each end are visited less frequently.

The part of the development which was most time-consuming was the design of the ball unit (there are 14 of these - it's the part which holds up to seven balls and then releases them when an eighth ball enters it). It was important that no ball was left in the column after a win, and that the bottom of the column was always closed afterwards. There would have been a lot of time wasted if, after the assembly of the machine, a flaw was found.

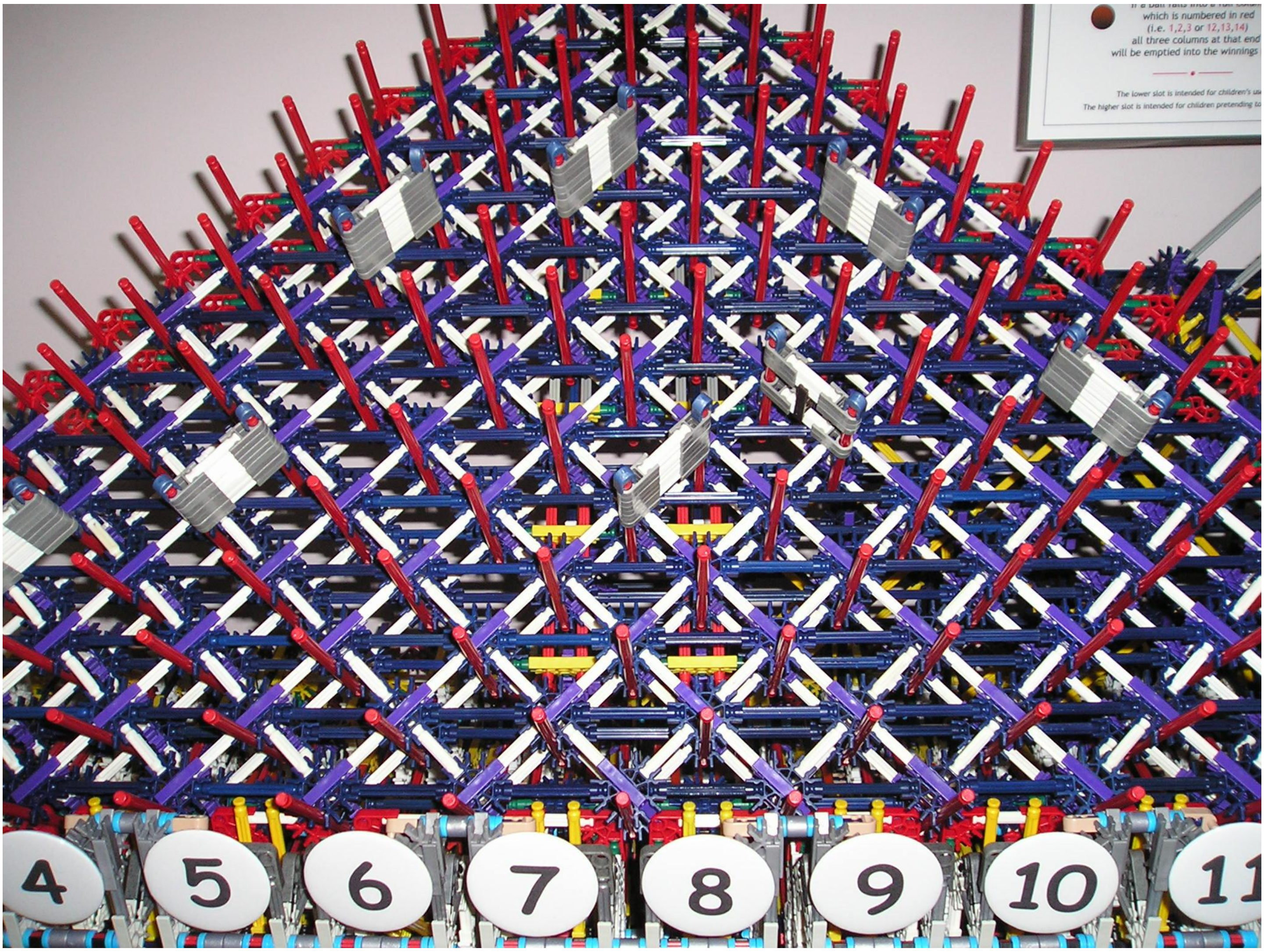
The centres of the ball units are 75mm apart.

The Balls

The balls are made of some kind of bouncy rubber (K'Nex balls are far too light for the mechanism to work). A box of new 400 balls was bought from an eBay seller. There were four different types of ball, about the same number of each. A quarter of them were slightly larger but about 20% lighter than the ones which were used and they didn't work very well. Another quarter felt slightly tacky, and the increased friction meant that they didn't work well either. The last quarter had a surface which was more like fabric than rubber, and they tended to slide down the pins instead of bouncing on them.

The balls used are pictured on the right. Each one weighs between 47 and 55 grams and no problems have been encountered (the weight is the same for identical designs, but some designs are heavier than others for some reason). Each ball has a diameter of 44mm, but they are not perfectly spherical: some diameters are as low as 43mm, and some are up to 45mm. These variations do not matter, because the ball unit has been tweaked so that all the balls work.

The Pinfield



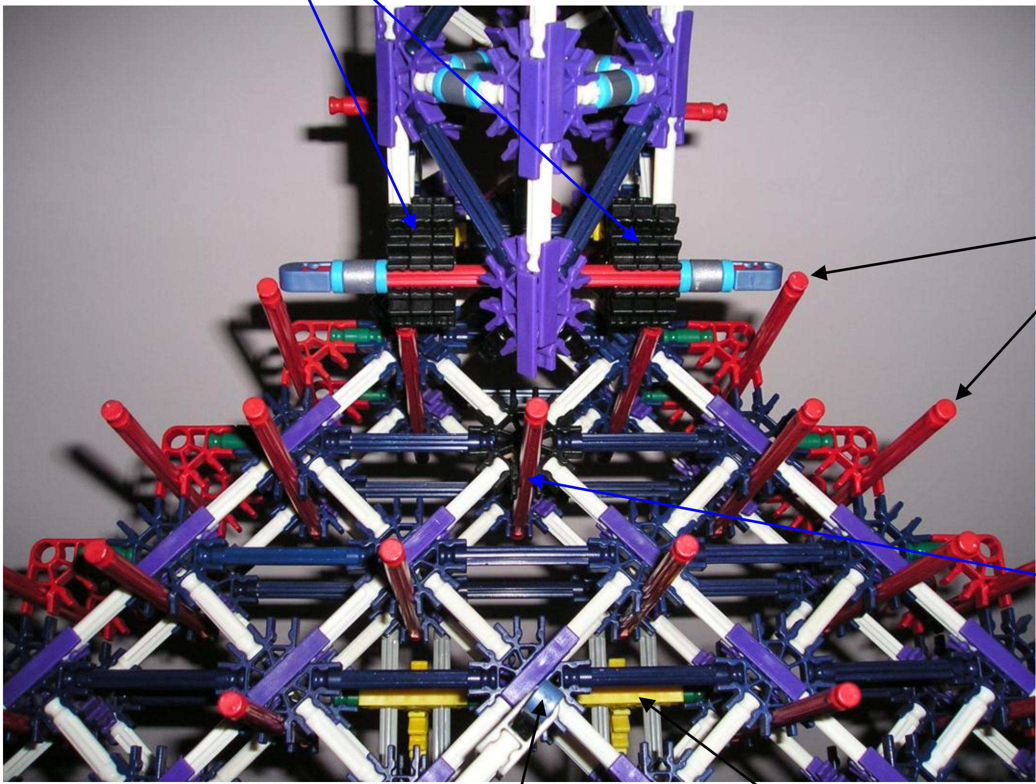
The above photo shows the construction of the pinfield (the yellow connectors in the layer underneath are used to attach the pinfield to its support). Note the construction of the blocker which is to the middle right – a brown 2-way connector has been used to hold the two white connectors apart. If the connector were made the same way as the others, a ball could get stuck because of the proximity of the blocker to its left.

Note also the layout of the purple 4-way 3-D connectors: their edges are aligned diagonally above the pins (red rods). This ensures that a ball can't get stuck above a pin (it is impossible to manually position a ball above a pin so that it stays there), but also creates a slight bias towards the left (on the left half of the pinfield) or to the right (on the right half), thus causing the three end columns on each side to be visited more frequently than would happen otherwise. The purple connectors down the middle of the pinfield alternate in direction, but the top middle pin – the one which an entering ball lands on – needed special consideration.

If there were a purple connector above the top pin, there would be a bias one way or the other, but this is one pin where a bias must not exist – the skew at such a high level would be completely unacceptable. An 8-way black connector has been used instead of 3-D connectors for this pin. By itself, this arrangement results in too many entering balls getting stuck above the top pin, and so a black rotational connector has been attached to it. In over 3000 trials, a ball has got stuck on the rotational connector just once.

K’Nex Ball Amusement Machine – The Pinfield

The entering ball must land dead centrally on the pin, otherwise there would be a bias; therefore, black 8-way connectors have been used to narrow the channel in order to achieve this aim.



THESE OUTSIDE PINS WERE NECESSARY BECAUSE A FAST-ENTERING BALL COULD BOUNCE OUT SIDEWAYS, BELIEVE IT OR NOT!

THERE IS A BLACK ROTATIONAL CONNECTOR POINTING UPWARDS ATTACHED TO THE RED ROD

THIS IS THE TOP OF ONE OF THE BLOCKERS

THE YELLOW CONNECTORS ARE USED TO ATTACH THE PINFIELD TO ITS SUPPORT

In spite of the attempt to remove bias, the pin below the entry pin creates a bias to the left. One way round this would be to have 8-way connectors all the way down the middle, but this was deemed inelegant. The blockers have been (asymmetrically) placed so that left/right bias in the two halves of the pinfield has largely been removed.

On the left is a view of the pinfield from the side. The two layers of the pinfield are separated by white rods. This produces a very solid structure, one which is able to handle the relatively heavy balls without flexing anywhere, producing solid-sounding bounces as the balls wend their way down.

On the right is a picture of one of the edges in more detail.

K’Nex Ball Amusement Machine – The Pinfield

Schematic Layout

In the diagram below, / and \ denote the flat edges of 3-D purple connectors (the extra pins round the outside are not shown here):

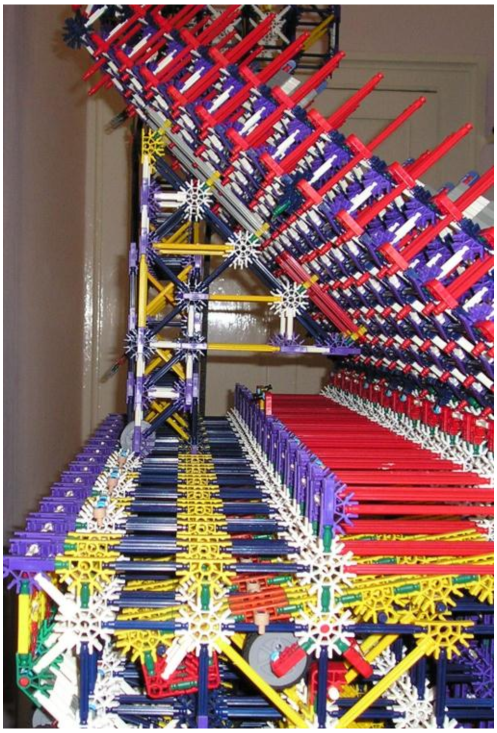
```
                          o   o
                        /       \
                        o   o   o
                      /   /   \   \
                      o   o   o   o
                    /   /   /   \   \
                    o   o   o   o   o
                  /   /   /   \   \   \
                  o   o   o   o   o   o
                /   /   /   \   \   \   \
                o   o   o   o   o   o   o
              /   /   /   /   \   \   \   \
              o   o   o   o   o   o   o   o
            /   /   /   /   /   \   \   \   \
            o   o   o   o   o   o   o   o   o
          /   /   /   /   /   \   \   \   \   \
          o   o   o   o   o   o   o   o   o   o
        /   /   /   /   /   \   \   \   \   \   \
        o   o   o   o   o   o   o   o   o   o   o
      /   /   /   /   /   /   \   \   \   \   \   \
      o   o   o   o   o   o   o   o   o   o   o   o
    /   /   /   /   /   /   /   \   \   \   \   \   \
    o   o   o   o   o   o   o   o   o   o   o   o   o
  /   /   /   /   /   /   /   \   \   \   \   \   \   \
  o   o   o   o   o   o   o   o   o   o   o   o   o   o
/   /   /   /   /   /   /   \   \   \   \   \   \   \   \
o   o   o   o   o   o   o   o   o   o   o   o   o   o   o

  1   2   3   4   5   6   7   8   9  10  11  12  13  14
```

Pinfield Support

Owing to the rigidity of the pinfield, and because most of the weight is concentrated on the middle, only a central support is needed.

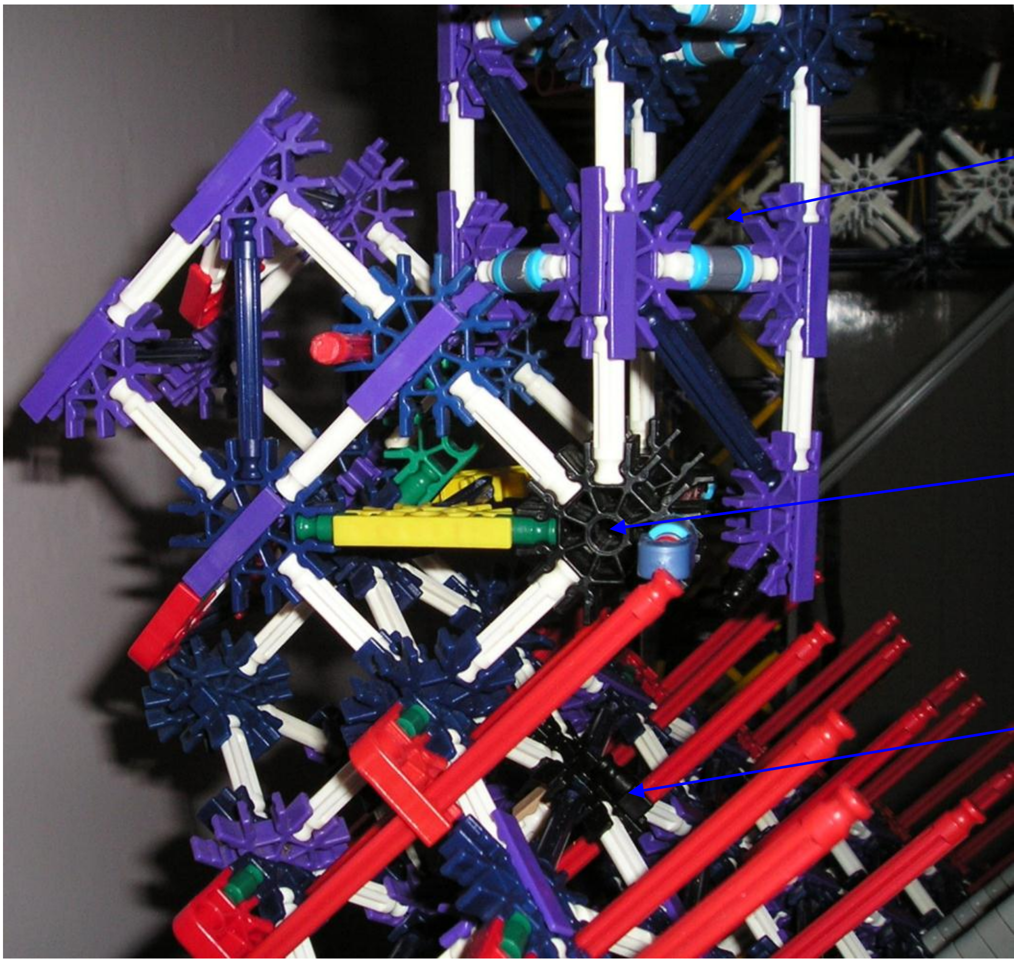
Some yellow connectors have been attached to the underside for the purpose.

The front of the pinfield basically rests on the ball units with a conveniently placed connector here and there – it is heavy enough not to move.



The Ball Entry

There are various ways in which the ball can be guided onto the pinfield. The picture below gives an indication of how it was down for this machine:



The Blockers

If there were no blockers, most of the balls would end up in the central columns, the end columns being visited rarely (even in view of the biases). In order to improve the balance, blockers have been placed to approximately even out the number of balls which fall in columns 4 to 11, and to increase the number of balls falling in the two columns at each end. The asymmetrical placing of the blockers was necessary to counteract the biases described earlier.

The Number of Columns

It should go without saying that the number of columns is arbitrary. It should be borne in mind that too few columns will not result in a satisfactory game, and too many will make the machine rather tall (and heavy, both in weight and consumption of pieces).

A machine with fewer columns could have a lower base so that no hoist is required; seven columns is a realistic minimum.