

## Small Lego Cube Construction Manual

In this document we describe and provide assembly instructions for a smaller version of the Lego X-ray calibration object detailed in [Knorlein et al. 2016](#). Like its larger counterpart, this “Small Lego Cube” contains 64 steel beads arranged in a 4x4x4 lattice. The following table compares the sizes of the two objects.

Object	Lego Cube	Small Lego Cube
Total # of points	64	64
Spacing between points	64 mm	<b>40 mm</b>
Individual marker size (diameter)	5 mm	<b>1/8” (3.175 mm)</b>
Overall size of marker lattice	192x192x192 mm	<b>120x120x120 mm</b>
Overall size of object	224x224x211.2 mm	<b>136x128x134 mm</b>

Required parts:

Part	Quantity
1/8” spherical stainless steel balls (McMaster-Carr Part # 9528K11)	64
1.2 mm diameter lead solder	~12 in.
2x4 Lego bricks Part #3001	208
2x3 Lego bricks Part #3002	24
2x6 Lego bricks Part #2456	5
1x2 Lego technic bricks Part #3700	64
2x2 Lego tiles Part #3068a	4

## Assembly Instructions:

### Part 1: Insert Beads

Press-fit one steel bead into the top cylinder of each 1x2 Lego technic brick, as illustrated in Fig. 1. Apply a small amount of superglue or other fast-drying adhesive to ensure the beads stay in place. Be sure to use consistent force when inserting the beads, so as to minimize variation in depth.



Figure 1. 1x2 Lego brick with 1/8” steel bead inserted into top cylinder.

## Part 2: Construct Reference Objects

Using lead solder, create four unique reference objects used for automatic calibration. In this manual, we use a jack, pyramid, helix, and 'dome' (Fig. 2). Center each object on a 2x2 tile and glue in place. The orientation of each object on the tile doesn't matter, so long as they're centered. **Be sure to place each shape in its correct location in the cube, as per the assembly instructions- the order matters. When calibrating in XMALab, click the origin of the line segments of the jack, and the approximate center of the other three objects.**

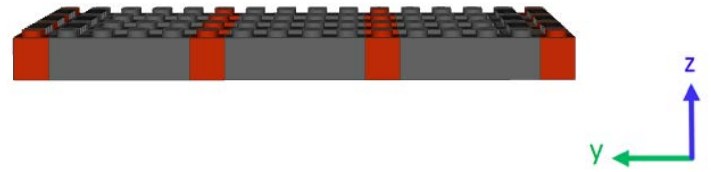
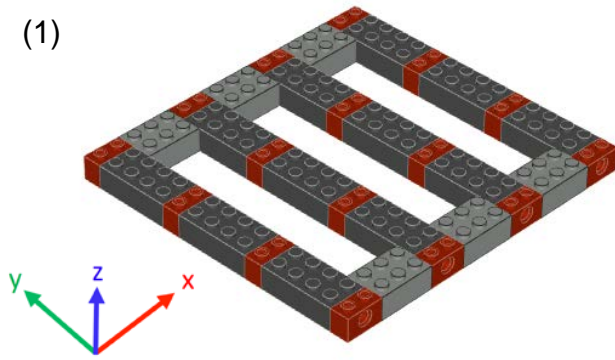


Figure 2. Reference objects created from 1.2 mm lead solder.  
(A) Jack. (B) Pyramid. (C) Helix. (D) Dome.

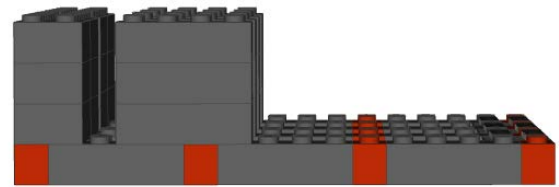
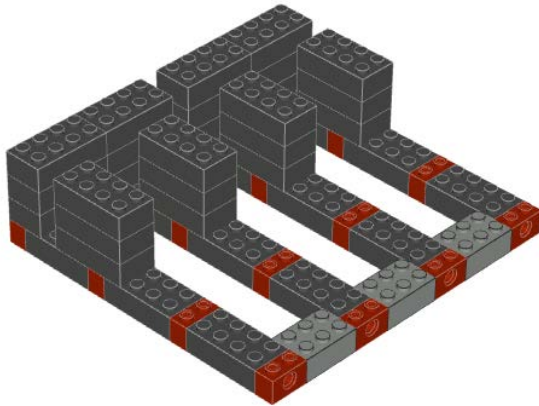
## Part 3: Assemble Cube

The following steps illustrate the assembly of the cube. Images were generated using open-source software Bricksmith (Allen Smith). The color of the bricks in the actual object doesn't matter, but we have color coded the images in the manual to aid comprehension. Red, 1x2 **with steel bead**; Dark grey, 2x4; Medium grey, 2x3; Light grey, 2x6. **Make sure all 1x2 pieces are oriented such that the bead-containing end is closest to the axes' origin (see axes in following images).**

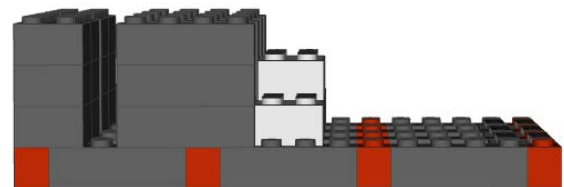
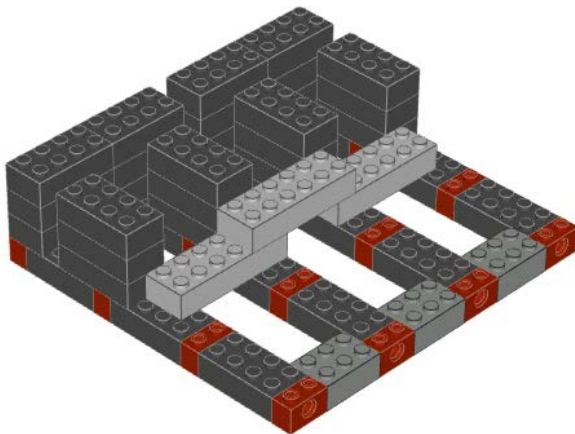
(1)



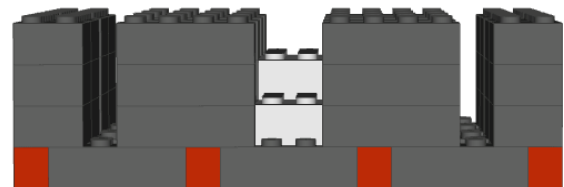
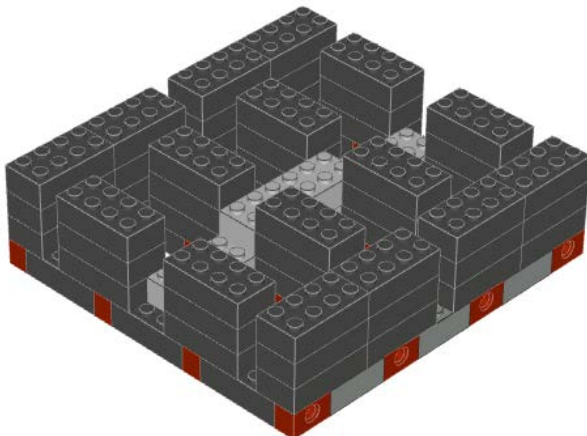
(2)



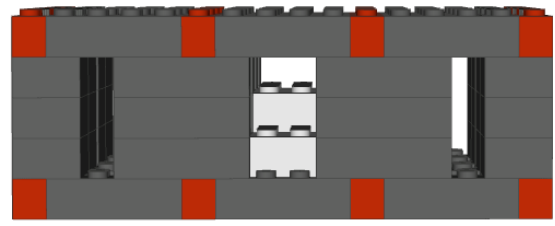
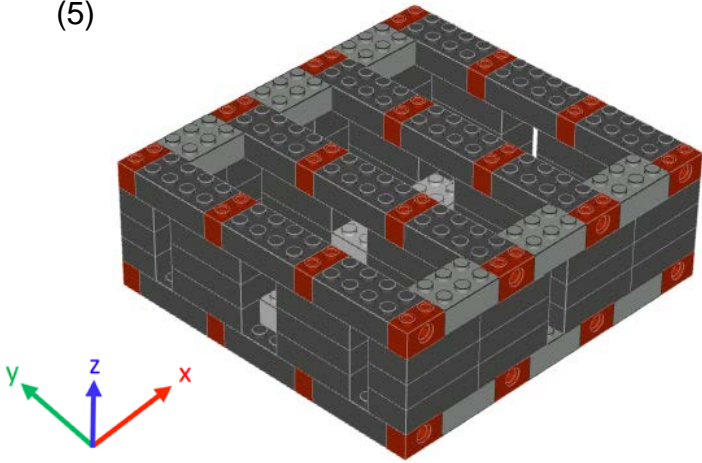
(3)



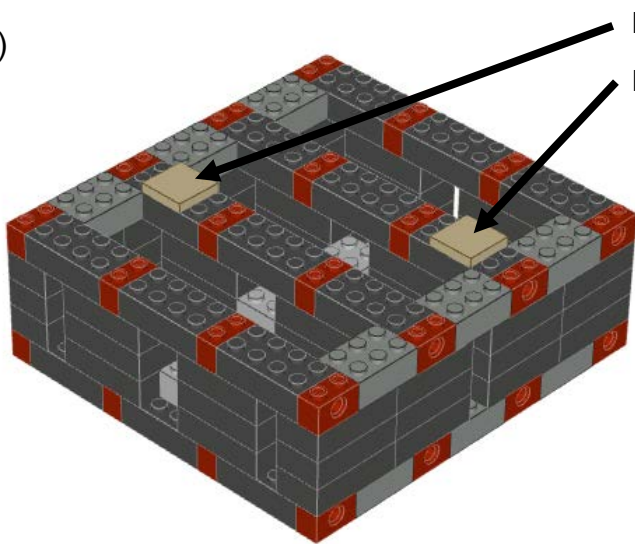
(4)



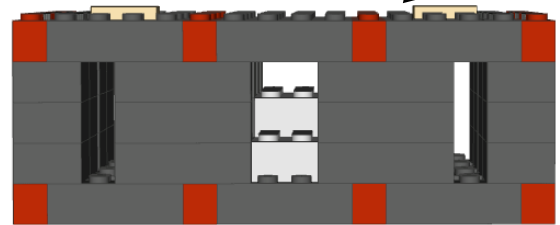
(5)



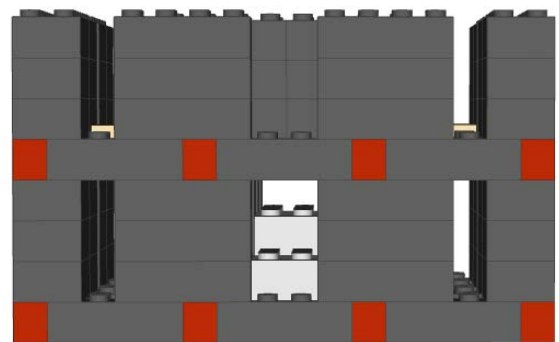
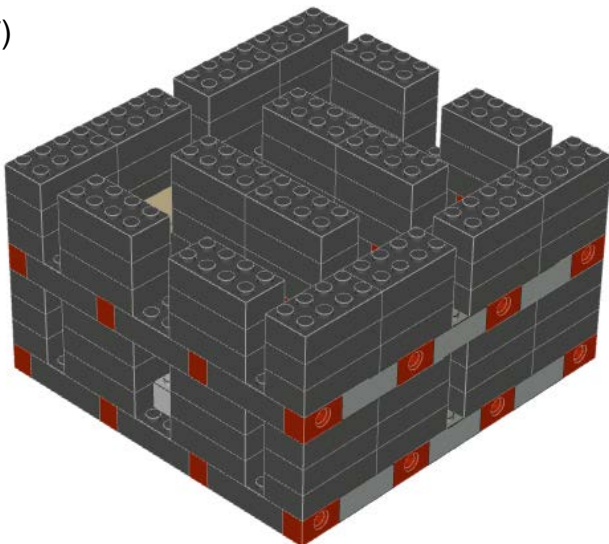
(6)



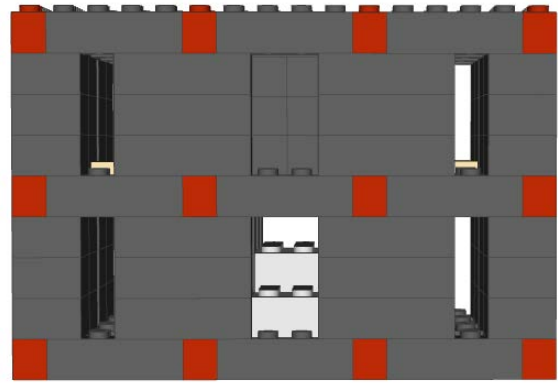
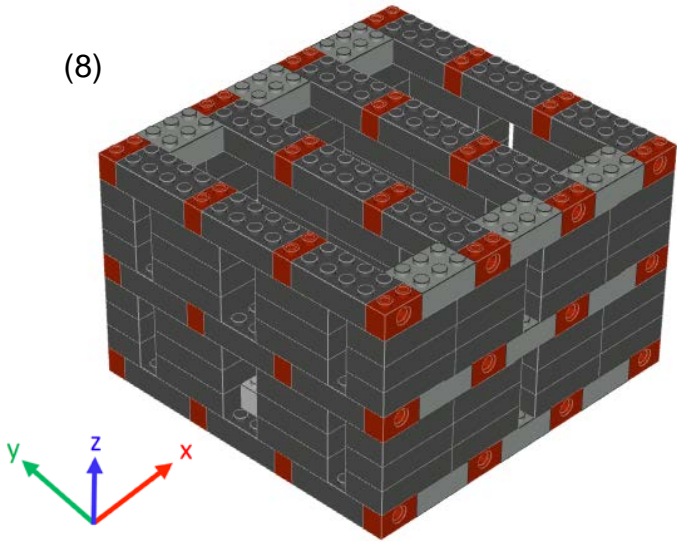
Helix  
Dome



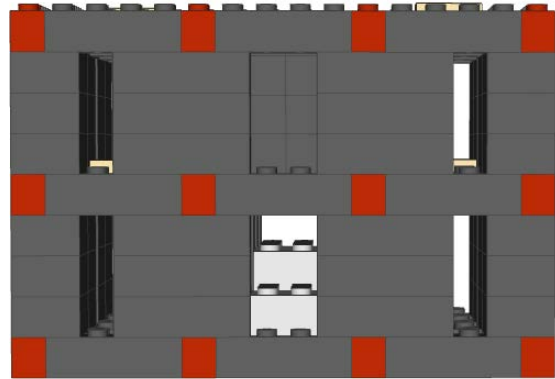
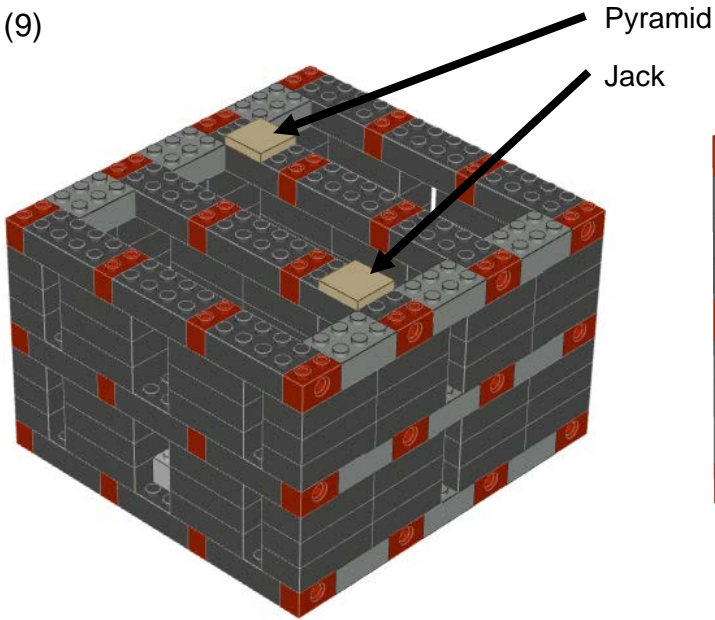
(7)



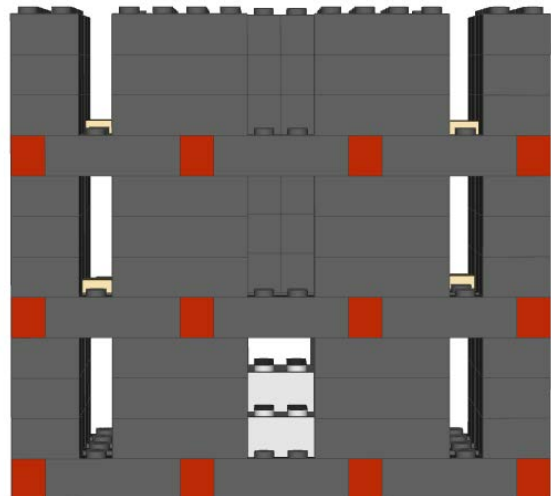
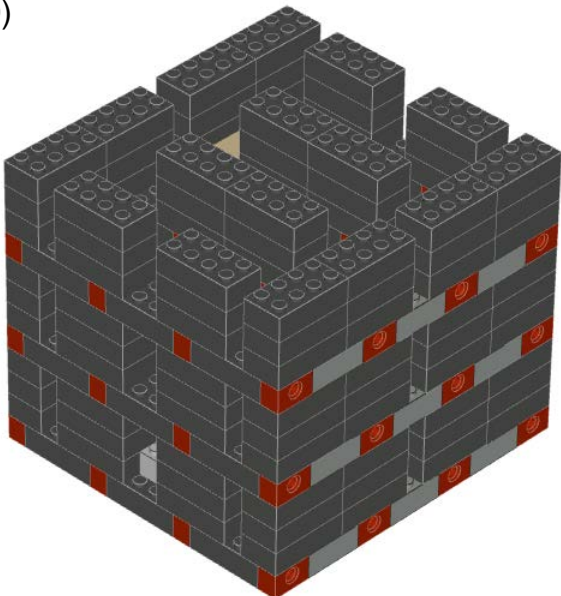
(8)



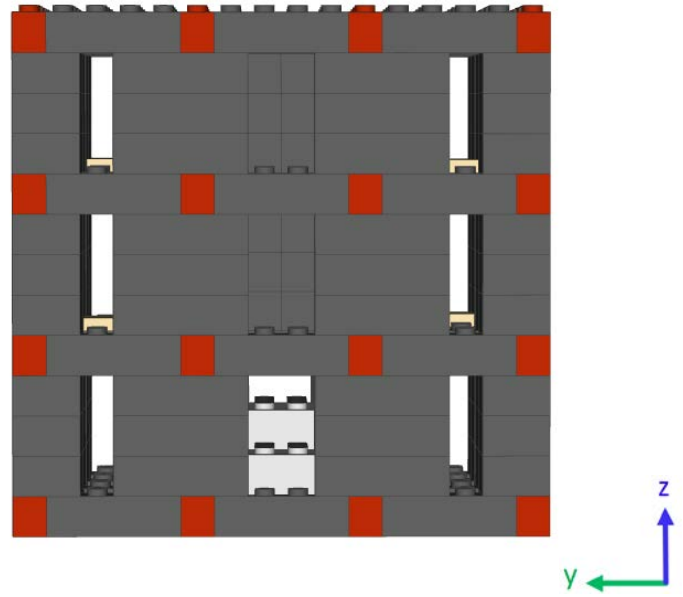
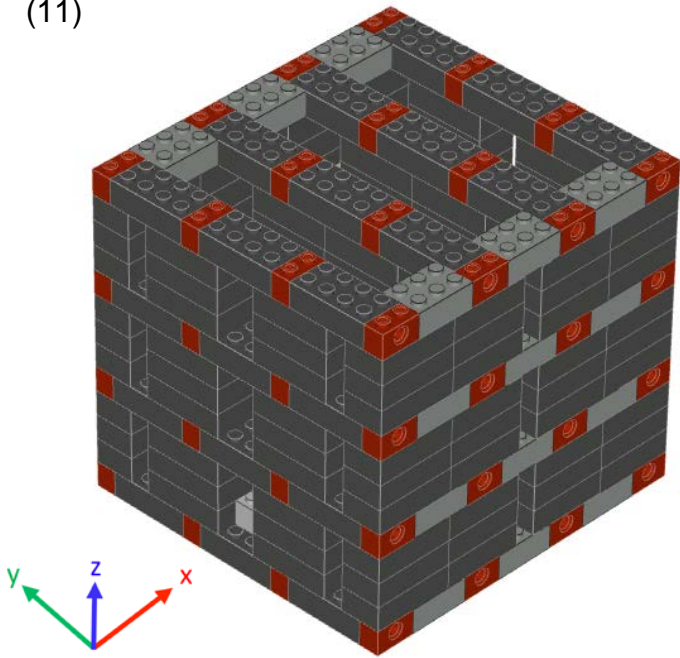
(9)



(10)



(11)



(12)

