Preliminary Construction Guide

for the

Educational Model Set

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These “instruction” pages are a sample of possible guides. The intent is to provide examples of how PolyLinx components fit together to form full models. These consist of a mix of notes and directions provided for CAD development.

Note: Some of the figures in this guide are based on a prior component versions. Please refer to the parts brochure for current part forms.
Tetrahedron

Upper Split Hub

Lower Split Hub

4x

And 6 Struts
Tetrahedron

Notice the orientation of the hubs.

While such placement is not required – the hub elements can be in any orientation – this allows the sides to more easily “fold” together.

These are upper split hubs on this side, forming a fixed equilateral triangle.

This is an upper split hub facing into the triangle.

These are the lower split hubs.
Tetrahedron

1) Fold lower split hub slot, A, and attached strut, B, up, towards the center.

2) Similarly, rotate the slot, C (lower split hub element).

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3) The left side will easily fold over to the right side

4) **Attach** the loose strut to the remaining open hub slot – Finished!
The Poly-Star (Stella Octangula)

or compound of two tetrahedra
The Poly-Star

The body nodes are built from full hinge-hub pairs and two secondary 90° hub elements.

The points (vertices) of the star are constructed from a pair of split hub elements.

And

8x sets

8x

36 Struts
The Poly-Star

Notice the Octahedron inside (in purple).
Let’s start with that.
The Poly-Star

Building the inner octahedron

Start with
6 Full hubs
12 Struts

1) Build Flat

Full hub

Primary slots - do not attach struts here

hinge axes

Proprietary, PolyBuilder Systems – all rights reserved
The Poly-Star

Building the inner octahedron

2) Fold Together

Connecting the strut ends A-E into their respective hub slots A-E as indicated. You will find that it is essentially ‘automatic’ when you are folding it together. A will really only want to snap into A, B into B...
3) Complete the first tetrahedron.
   Do this by adding ‘tetra-points’.

Tetrahedron to come

Empty primary slots

4 sets of Split Hubs

Tetra-point
The Poly-Star

Snap the tetra-points to the octahedron.

Completing the base tetrahedron.
The Poly-Star

3) Build out the second tetrahedron by adding a second set of tetra-points
The Poly-Star

Adding the Final Points
Assemble 4 sets of “tetra-points”, this time adding secondary slots to them.

The tetra-points are then snapped onto the full hubs, completing the star.
An Alternate way to build the is show in brief, below.

This is an approach that can be used on many PolyLinx structures, and that is to ‘build it flat”, then “fold it together”.

In this approach, orientation of the hubs is important, not just the axis. This will allow larger sides to ‘fold’ relative to the other.

For the Poly-Star, the base tetrahedron is built this way, then four tetra-points are added (not shown).

In the diagram below, it may be clear that the left half is free to rotate about the y-axis (indicated) independent of the right half.

Large multi-level structures can be built up in this manner and “folded together”.

The Poly-Star

Alternate Construction
Build it Flat - “Fold” it together.

When you fold it, the pairing of the struts into their respective slots will be obvious.

Complete the star by going to “Adding the Final Points”, above.
The Butterfly Structures

Octahedron
6 vertices = 6 hubs
12 struts

Cuboctahedron
12 vertices = 12 hubs
24 struts

Icosidodecahedron
30 vertices = 30 hubs
60 struts

These polyhedra are constructed using only the Butterfly Hinge-Hub and Struts
Every vertex (hub) can be viewed as two equilateral triangles meeting, and two regular polygons: a triangle, a square, or a pentagon. Each is derived by changing the angle, $\alpha$, between the opposing triangles.

<table>
<thead>
<tr>
<th>Polyhedra</th>
<th>adjacent polygon</th>
<th>*angle $\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Octahedron</td>
<td>Triangle</td>
<td>$\cos^{-1}(1/3)=70.53^\circ$</td>
</tr>
<tr>
<td>Cuboctahedron</td>
<td>Square</td>
<td>$180-\cos^{-1}(1/3)=109.47^\circ$</td>
</tr>
<tr>
<td>Icosidodecahedron</td>
<td>Pentagon</td>
<td>$2\sin^{-1}((1+\sqrt{5})/2\sqrt{3})=138.19^\circ$</td>
</tr>
</tbody>
</table>

*Not to worry, you don’t need to know these angles. Simply fold the hinges until opposing pieces meet, and there you go!*
The Butterfly Structures

The Octahedron

6 vertices
12 struts

1) Build Flat
2) Fold Together!
- attach struts as indicated

You may notice that unlike the tetrahedra, where the axis of the hinge-hub aligned with the edges or struts of the triangles, here the hinge axes are not aligned with the edges.
The Butterfly Structures
The Cuboctahedron

12 vertices
24 struts

Build Flat as indicated.
Fold together, attaching struts to hubs as shown, Strut A to Slot A, etc.
Hub E will collect-up remaining struts.
A Few Hex Structures

Truncated Tetrahedron

Truncated Octahedron

Truncated Icosahedron (Bucky Ball)

Note that all of these structures include a hexagon. They are built with the same PolyLinx elements used in the Nanotubes.

Each identical hub may be constructed of a half-hub and a half butterfly – the Beetle Hub

The difference in construction is how far the inner angle of the hub is opened.
Similar to the Butterfly structures, this can be
1) Built FLAT as a set of Hexagons, then
2) Folded together.
Truncated Icosahedron (Bucky Ball)

The truncated icosahedron models the soccer ball and the $C_{60}$ carbon molecule.

It consists of 60 vertices (hubs) and 90 edges (struts). The surface is made up of regular hexagons and pentagons. The inner angles of the hexagons and pentagons are $120^\circ$ and $108^\circ$ respectively. The dihedral angle – that is, the angle between adjacent hexagons is $138.19^\circ$.

Each identical hub may be constructed of a half-hub and a butterfly...

Fortunately, for the novice builder, no setting / adjustment of the angles is necessary... when you build it, it will “automatically” have the correct angles.
The Dodecahedron

The Dodecahedron is one of five Platonic Solids, where all the edges are the same length, all of the faces are identical polygons, in this case, pentagons, and where all of the angles of the polygons are the same (equiangular). The dodecahedron is made up of 12 pentagons, with a total of 20 vertices (hubs), and 30 edges (struts).

Construction is similar to the truncated icosahedron, but rather than fixed angle hubs, slider hubs are used.

20 Hubs – consisting of:
- Slider
- Slider with no primary slot
- 2 Slider slots

Tech Specs
- Inner angle of the pentagons: 108 degrees
- Angle between faces (the dihedral angle, δ): $180 - \tan^{-1}(2)$ or 116.56°
- When folded, the angle between the two sliders is geometrically “forced” to 108°
The PolyLinx Nanotube

Nanotube I

This basic nanotube construction is of a “zigzag” nanotube (n,0). Other nanotube structures may be built with PolyLinx.

This uses the Beetle Hub configuration as shown at right, consisting of a Half Hub and a Half Butterfly. The ends of the nanotube use a split hub pairs.
The PolyLinx Nanotube

This basic nanotube construction is of a “zigzag” nanotube (n,0). Other nanotube structures may be built with PolyLinx.

Dodecagon
Inner angle = 150°

150° is the angle each hinge-hub will be “folded” for a 6 hex diameter nanotube

End View – looking through a nanotube

Hexagon
Inner angle = 120°

Side View – A single nanotube “cell”

Use 1-5/16” struts for this design
The PolyLinx Nanotube

Start by making a flat hex lattice

Hubs:
- Half-hub + Butterfly

Make sure the primary axes of all of the hub elements align vertically – this will be the direction of the tube

End of Tube

Full upper split hub (2 pieces) x 6 for hinges at end of tube
2x to include other end of tube

Butterfly hinge elements are on same side of strut – this makes it easier to “roll” the tube

Butterfly hinge elements are on opposite sides – this makes it a little harder to “roll” the tube (the rolling relies on the struts rotating in the slots) but makes for a more rigid structure.

Short struts are used in this design.
The PolyLinx Nanotube

6 hex circumference by 7 hex long

6.5” diam x 22” long

Each hub is made of 1 Half plus 1 Butterfly hub element

Spilt Hub Pair (2 pieces ea) x 6
2x to include upper end of tube

Direction of tube (length)

Roll this way, attach

Leave these struts bare – they will attach to the open slots on the other side when you roll the tube.
The PolyLinx Nanotube II

This construction is of an “armchair” nanotube \((n,n)\).

Notice that the direction of this nanotube different than the “zig-zag” nanotube. Both types are forms of molecular carbon.

This nanotube can be constructed using hubs made of 2 slider hubs-no primary and 3 slider slots.
The PolyLinx Nanotube
Nanotube II

Short struts are used in this design
Space Cruiser

Side panel struts: 3.4”
Cross struts: 5.125”
The Space Cruiser model is strictly representative of possible models / kits that could be developed based on PolyLinx. It is assumed that additional design work, such as for rocket booster design, etc. would be required for completion. One alternative is that components ancillary to PolyLinx could be form and fit with Lego type building blocks.

Another model in a similar vein is the flying saucer.
Geodesic Domes

Advanced

3v  5/9  Geodesic Dome

2v  1/2  Geodesic Dome

4v  6/12  Geodesic Dome
2v 1/2 Geodesic Dome
## 2v 1/2 Geodesic Dome

### Parts

<table>
<thead>
<tr>
<th>Parts</th>
<th>qty req’d</th>
</tr>
</thead>
<tbody>
<tr>
<td>A struts</td>
<td>30</td>
</tr>
<tr>
<td>B struts</td>
<td>35</td>
</tr>
<tr>
<td>Penta hinge</td>
<td>6</td>
</tr>
<tr>
<td>6-way full flex hinge</td>
<td>10</td>
</tr>
<tr>
<td>4-way (dome edge) hinge</td>
<td>10</td>
</tr>
</tbody>
</table>

### Hub element totals

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>upper slider elements</td>
<td>36</td>
</tr>
<tr>
<td>upper split elements</td>
<td>10</td>
</tr>
<tr>
<td>upper-no primary slider</td>
<td>6</td>
</tr>
<tr>
<td>lower slider elements</td>
<td>32</td>
</tr>
<tr>
<td>slider slots</td>
<td>82</td>
</tr>
<tr>
<td>split clips</td>
<td>6</td>
</tr>
<tr>
<td>hinge clip sets (40 elements)</td>
<td>20</td>
</tr>
<tr>
<td>struts (2 custom lengths)</td>
<td>65</td>
</tr>
<tr>
<td>Total parts</td>
<td>257</td>
</tr>
<tr>
<td>parts counting 2 per hinge clip</td>
<td>277</td>
</tr>
</tbody>
</table>
Again, there is no need to manually set the angles between the struts. All of the angles of the Geodesic dome are determined by the geometries of the dome and the given fixed strut lengths. Simply “build it”; the various angles will define themselves!
The Gherkin
Saint Mary Axe, London

Build with butterfly sliders: Each hub includes 2 slider on hub w/ no primary, 4 slider slots
This 3D molecular lattice is a very straight forward design, requiring only full slider hubs, secondary hubs and struts.