Zometool Project Series: the world's most powerful (and fun!) modeling system. Kids, educators, and Nobel-prize winning scientists all love Zometool:

- it's unique, brilliant, beautiful
- all kits are compatible—more parts, more power!
- guaranteed for life!

"The mind, once stretched by a new idea, never regains its original dimensions." –Oliver Wendell Holmes

Crazy Bubbles

Parts: 72 *(plus a straw)

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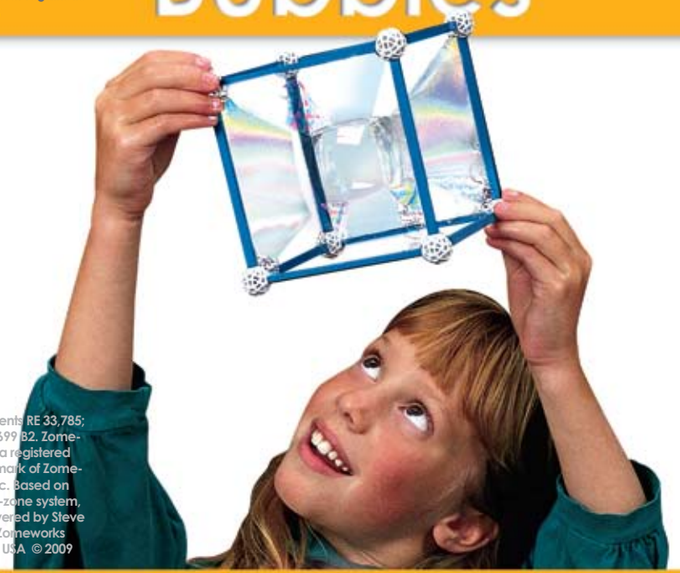

HAVE YOU EVER SEEN A SQUARE BUBBLE?

Discover a world of bubbles you never knew existed! Learn all about bubbles—for BUBBLY SCIENCE PROJECTS—or just plain Zometool fun!

You can create:

- *Bubbles shaped like a CUBE!*
- *BANANA-shaped bubbles!*
- *Bubble-faceted jewels!*
- Even SPIRAL bubbles!

MADE IN USA from kid-safe materials

7 09743 20031 8

WARNING: Choking Hazard

SMALL PARTS. NOT for children under 3 years.

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START HERE!

The secret super bubble recipe:

1. Find a container to hold 10 *liters* (2.5 *gallons*) of *warm water*. A deep sink or a 5 gallon bucket works well*.

2. Start by adding 125 mL (milliliters, or 1/2 *cup*) *liquid dishwashing detergent*. Most dishwashing liquids work, although generic and antibacterial products are not recommended. In the USA, we find that regular *Dawn* and *Joy* work the best.

3. Mix the bubble solution gently with your hand. For crystal-clear bubbles, be sure to *keep the surface free of foam*.

You may add extra detergent if you can't form bubbles or if they pop too easily.

Tips for better bubbles:

Add 15 ml (1 tablespoon) of glycerin (from any drugstore) for tougher, longer-lasting bubbles.

Bubble solution improves with age. If you can, leave the mixture in an open container for at least one day before use.

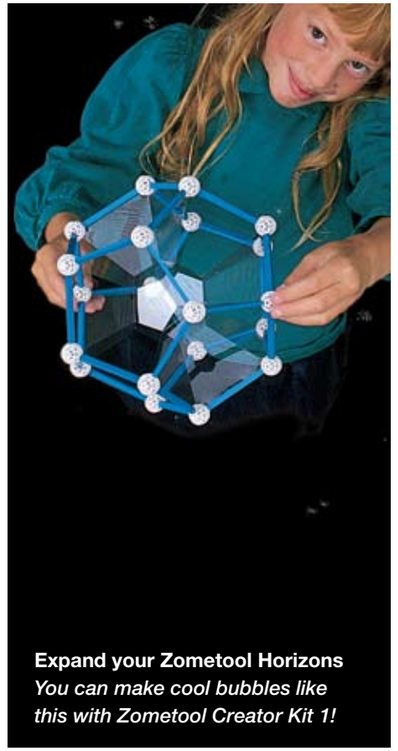
Sometimes water supplies contain impurities that make it difficult to form good bubbles. You may consider using filtered tap water, or distilled water from your local supermarket.

Very dry air will shorten the life of your bubbles. Try using a humidifier.

A slight breeze can warp bubbles. You get the best bubbles in an enclosed space—like a classroom, garage, or kitchen. So stay inside... but we don't recommend making bubbles over a wooden floor.

Avoid Accidents: store bubble solution out of reach of children. If it gets in eyes, rinse thoroughly with water. If swallowed, dilute with a glass of water.

*You can often get a 5-gallon bucket free from your school food service or a local restaurant!

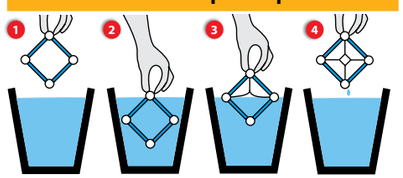


Expand your Zometool Horizons
You can make cool bubbles like this with Zometool Creator Kit 1!

Create models *(inside)*; make cool bubbles!

Use the step-by step instructions on the other side of this sheet to build models. Then follow these steps to make cool geometrical bubbles!

The simple dip



1. Hold your model by one ball.

2. Dip it into the bubble solution. (Dipping at an angle works best.) Be sure that the model is submerged completely.

3. Gently lift the model out of the bucket, so the bubble solution "clings" to every strut.

4. PRESTO! – you should have an interesting geometrical bubble!

More advanced tips and tricks follow.

Some dipping tips:

- Clear the surface regularly of excess foam.
- If it's windy (even a little breezy), stay inside.
- Simpler structures make the best bubbles.

- Use a wet finger to "re-arrange" your bubble (try it!), a dry finger to pop parts of your bubble and get crazy curves!

Catch some air, dude: create a "bubble inside a bubble!"

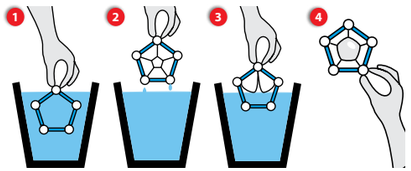
1. Completely submerge your model.

2. Gently pull it completely out of the bucket.

3. Dip one side again, about a third to halfway into the solution.

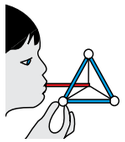
4. You've trapped a bubble of air inside.

Use this method to make the dodecahedron bubble (see Advanced Models, right).



Using the straw

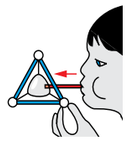
1. Create a "Simple Dip" (see left column).



2. Dip the straw into the bubble solution.

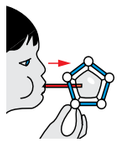
3. Gently touch the wet end of the straw to the bubble intersections.

4. Blow air into the bubble with your straw (but don't breathe in soap). You'll get a bubble within a bubble.



Changing the size of your bubble

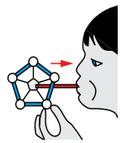
1. Wet your straw in the bubble solution. (If the straw is not wet, the bubble will burst.)



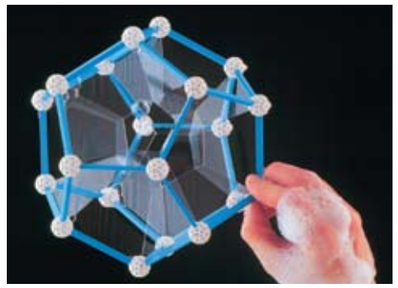
2. Next, put your straw into the bubble.

3. If you want the bubble to be bigger, gently blow air into the shape.

4. To make it smaller, blow out any excess soap suds from the end of the straw, then gently breathe in to pull air from the bubble.



Advanced Models: Here are two more great bubble models that you can build with additional parts from other Zometool kits:



- Dodecahedron (12-sided polyhedron—this requires the Zometool Creator Kit 1). See "Catch some air" and other tips (left) for hints on creating this special bubble.
- Octahedron (an 8-sided polyhedron—use *Pure Carbon* or *GreenLines*). With practice, you can make a bubble showing the crystalline structure of diamond!

The way of the Zometool bubble

Bubbles form because of the *surface tension* of water. Hydrogen atoms in one water molecule are attracted to oxygen atoms in other water molecules, and cling together. Bubbles enclose the *maximum volume of air* with *the minimum bubble solution*, so they are normally round. Zometool bubbles are also *minimum surfaces*, i.e., they're the most efficient way to link the balls and struts with surfaces. The surface tension of water, alone, is *too strong* to make good bubbles -- *adding soap reduces surface tension*. It also adds oily film that slows down the evaporation process, so you get longer-lasting bubbles! *(You can model water and soap molecules with our Molecular Mania project.)*

Zometool's bubbliography

Bubblemania
Durant, Penny Raife.
New York: Avon Books, 1994.
Secrets to making spectacular bubbles!

Soap Bubble Magic
Simon, Seymour.
New York: Lothrop, Lee & Shepard, 1985.
Learn everything about soap bubbles.

Bubbles
Zubrowski, Bernie.
Boston: Little, Brown, 1979.
Fun with gigantic soap bubbles, sculptures and unusual bubble shapes.

Bubble-ology
Lawrence Hall of Science, GEMS.
Berkeley, CA: The Regents of the University of California, 1986.
A book so fun, we sell it on our own site at www.zometool.com! Includes a teaching guide to loads of bubble experiments. Kids measure, classify, draw conclusions, adjust, average — even graph results!

Soap Science: A Science Book Bubbling with 36 Experiments.
Bell, J. L.
Reading, MA: Addison-Wesley, 1993.
Investigate soap bubbles to test water, soap and aspects of electricity, light and other science topics.

Advanced books:

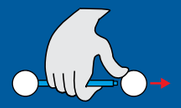
Soap bubbles, their colours and the forces which mold them
Boys, Sir Charles Vernon,
New York, Dover Publications, 1959
"Being the substance of many lectures delivered to juvenile and popular audiences with the addition of several new and original sections."

The Science of Soap Films and Soap Bubbles
Isenberg, Cyril
New York, Dover Publications, 1992
Simply the best book on the subject!

ZOMETOOL RULES!

1. *If it works, it works perfectly.*

2. *Don't break it apart; take it apart!*



3. *Don't crush models.*

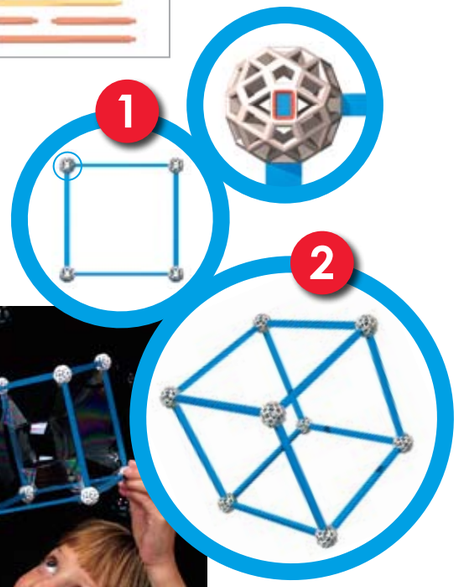
Our mission:
- make learning fun
- create value
- build a better world

Discover more at **zometool.com**
or call **888-966-3386** or **303-297-3387**.

Zometool Crazy Bubbles Project — thanks to Dr. Veit Elser (and daughter), concept; Yasu Kizaki, development and copy; Dr. Scott Vorthmann, vZome software for images; Tara Brouwer, Anni Wildung and Dale Hess, graphic design; Paul Hildebrandt, editing and project management, contact paulh@zometool.com. Based on the 31-zone system discovered by Steve Baer, Zomeworks Corp., USA.

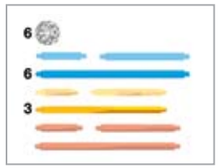
Hypercube

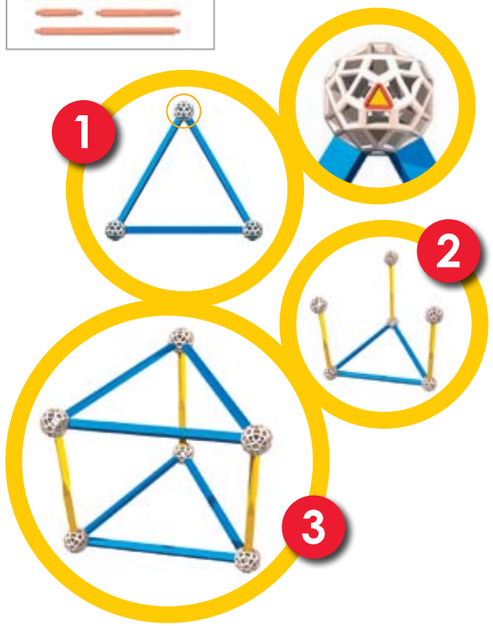
When you make a square bubble in the middle of the cube, you get a perspective shadow of a 4-dimensional cube. In mathematics, higher dimensions are just as real as our 3-D world!



Prism

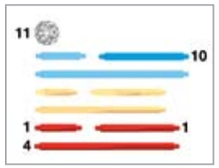
When you dip this prism, the lines that appear in the bubble reveal the shortest length of a network that connects each of the corners. In the field of communications, bubbles have been used to identify ideal routes for data transmission!

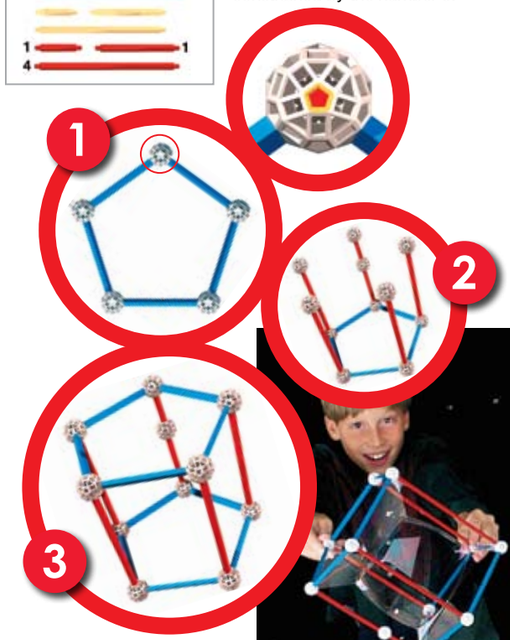




Pumpkin

A pumpkin encloses the maximum volume of seeds within the smallest skin surface using 5-fold symmetry. When a "pumpkin" bubble appears inside this 3-D pentagon, it is also constrained by the number 5.

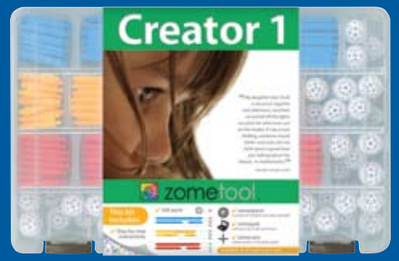




Here Are a Few Fun Factoids about Soap Bubbles!

- **WHAT IS A BUBBLE?**
  A thin skin of liquid surrounding a gas.
- **WATCH THE COLOR** on top of a bubble! It's a clue as to when the bubble will pop: As your bubble becomes thinner, the INTERFERENCE caused when light waves collide changes the color of your bubble. Scientists found a special sequence of colors: first green, then blue, magenta, yellow, green, white, white with black spots, black... POP!
- **HOW THIN CAN A BUBBLE GET?**
  Just before it pops, a bubble is only ONE MILLIONTH OF AN INCH THICK!
- **WHAT'S THE LIFE SPAN OF A BUBBLE?**
  The longest-living bubble lasted for 340 DAYS! Eiffel Plaster made the bubble and holds the record.
- **WHEN 3 BUBBLES COME TOGETHER,** they always join to form a 120-DEGREE angle— the same way honeycomb cells are packed together. It's nature's way of finding the most efficient way to fill space!

For more, bigger, better bubbles...



Build the dodecahedron (page 3) and lots more.

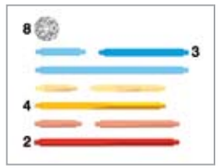
Make bubble carbon atoms and diamonds!

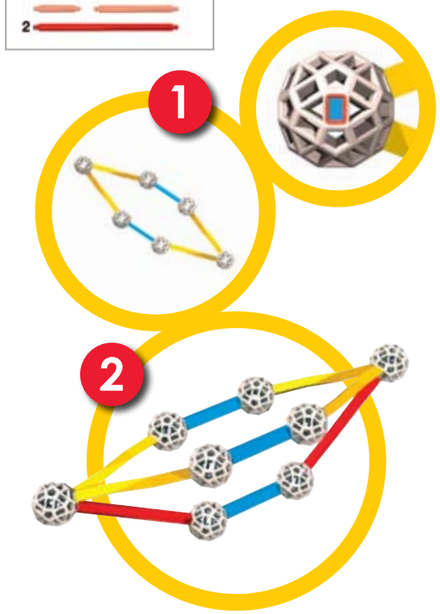
For the regular octahedron (page 3) and crazier bubbles.

Build familiar molecules, like water and soap.

Banana

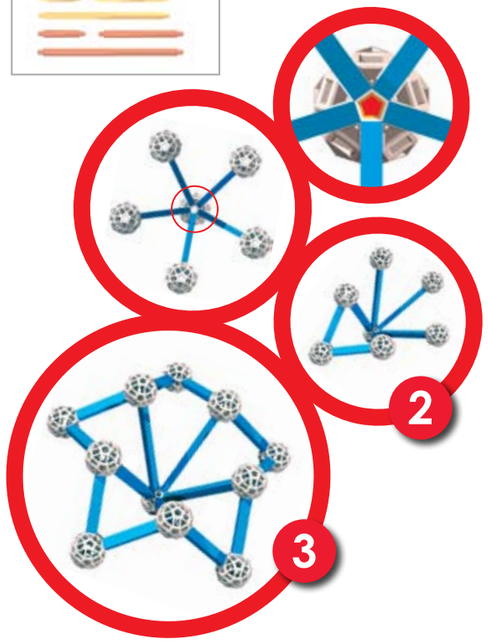
The banana is a minimal curve divided into 3 sections. Nature uses 2-fold, 3-fold and 5-fold symmetries in designing plants and animals. You'll find 2, 3 and 5 in the shapes of Zometool parts (rectangle, triangle and pentagon)!





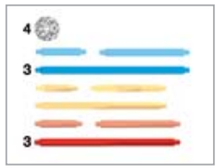
Flower

The petals of this flower are 5 saddle-curves joined together. The number 5 is the mathematical seed of the Divine Proportion, found in art as well as nature. Zometool struts come in Divine Proportion lengths!



4D Triangle

When you dip this shape, bubble-lines are formed that automatically meet at the very center of the 4-D triangle. In chemistry, this shape is known as a tetrahedral bend, and it is the secret of a diamond's strength.



Spiral

The spiral is related to the shape of DNA. The DNA molecule is the blueprint of all life on earth! *Check out our Zometool DNA project.*