

Structures

G.A.C. Pack

Here are some constructive ways
for you and your partner
to engineer the science of structures.



A national collaboration to encourage
family involvement in girls' science learning

Developed for Girls at the Center, funded in part
by the National Science Foundation.
© 2000 by Girl Scouts of the United States of America
and The Franklin Institute



*This G.A.C. Pack has been made possible through
generous support from:*

National Science Foundation
Lockheed Martin Corporation
General Motors Foundation
The UPS Foundation
The St. Paul Companies
Merck Company Foundation and
Crum & Forster Insurance
The William M. King Charitable Trust
Minnesota Mining and Manufacturing
Foundation, Inc. (3M)
The Valentine Foundation
First Union
The Boeing Company
Alcoa Foundation
Bank of America
George and Frances Armour Foundation
Best Buy Children's Foundation

REACH FOR THE SKY!

Did you know that:

the term skyscraper originated in the United States in the 1880s after buildings in New York reached 10 stories? A skyscraper or high-rise building is a multi-storied building constructed on a steel skeleton. It combines extraordinary height with ordinary-sized rooms.

the world's tallest building is the CN Tower in Toronto, Canada, which is an imposing 1,815 feet, 5 inches (553.33 meters) tall? The CN Tower is taller than the Sears Tower in Chicago, which stands at 110 stories (1700 feet).



Partner Challenge

Build the best structure that you can, using the materials listed below. What makes your structure the best? Its stability?

Its height? (Measure and record the height of your structure.)

Its ability to hold up heavy objects? (How many books or magazines will your structure hold up?)

You will need:

- ◆ 20 paper clips
- ◆ 30 straws
- ◆ Masking tape
- ◆ Books or magazines
- ◆ A ruler

Construction Tip: Connect the straws using paper clips.

BUILD A PYRAMID

The pyramids are one of the wonders of the ancient world. Did you ever wonder how they were built? Make a scale model of the Great Pyramid at Giza with your partner.

You will need:

A thin piece of cardboard or construction paper (8 1/2 inches square)

Scissors

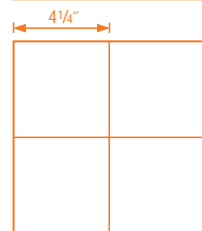
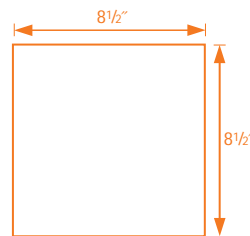
A black pen

A red pen

A blue pen

Tape

A ruler

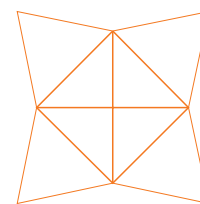
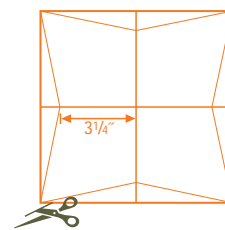


What to do:

1. Cut the paper or cardboard so that it is 8 1/2 x 8 1/2 inches.

2. Mark the midpoint (4 1/4 inches) on each side. Draw a black line connecting opposite center points.

3. Make a dot 3 1/4 inches out from the center on each of



the four lines. Draw a red line from each corner of the paper to each dot you just marked. Cut along the red lines and throw away cuttings.

4. Draw blue lines connecting the dots to form a diamond shape.

5. Fold along the blue lines and tape the edges together.

Fascinating Fact:
The real pyramid is almost 2,000 times larger than your model!

Girl Scout Program Links

For Brownie Girl Scouts:

Discover the world of shapes and structures with the **Building Art and Number and Shapes** Try-Its.

For Junior Girl Scouts:

Explore careers in engineering, including bridge building, with the **Science in Action** badge. Design your ideal living space with the **Architecture** badge.

For Cadette and Senior Girl Scouts:

Create environmentally friendly buildings with the **Architecture and Environmental Design** interest project award. Learn about computer design programs, architectural blueprints, and engineering design decisions with the **Build a Better Future** interest project.

BOOKS ABOUT BUILDING



The Brooklyn Bridge: A Wonders of the World Book, by Elizabeth Mann. Mikaya Press, 1996. Experience the wonder of building this fantastic suspension bridge and the story of the people who made it happen. Great photos! (Ages 9 —12)

The Capitol (Cornerstones of Freedom), by Andrew Santella. Children's Press, 1996. Enjoy the art and architecture of our nation's capitol building. (Ages 9 —12)

Bridges, by Etta Kaner. KidsCan, 1997. A step-by-step guide to building bridges using everyday household items. (Ages 9 —12)

The Library of Congress: An Architectural Alphabet. Pomegranate, 2000. A beautiful picture book of a famous Beaux Arts building. The alphabetical glossary is a fun way to learn architectural terms. (All ages)

Maya Lin, by Bettina Ling. Raintree, Steck-Vaughn, 1997. At the age of 21, Maya Lin won a competition for her design of the Vietnam War Memorial. Read about this very special architect, artist, and monument designer.

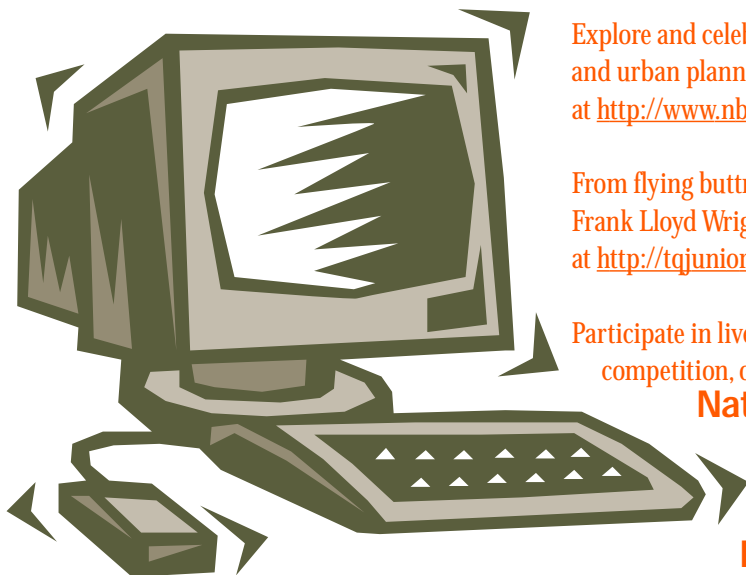
HOT LINKS

Explore and celebrate architecture, design, engineering, construction, and urban planning by visiting the **National Building Museum** at <http://www.nbm.org>

From flying buttresses to skyscrapers and from Michelangelo to Frank Lloyd Wright, learn about **Architecture Through the Ages** at <http://tjunior.advanced.org/3786/index.html>

Participate in live chats with female engineers, enter the "city of the future" design competition, or learn about great building activities when you log on to the **National Engineering Week** site at <http://www.eweek.org/>

Have you ever wondered why bridges don't fall down? Take a virtual reality walk across **San Francisco's Golden Gate Bridge** and discover some fascinating facts about building bridges at <http://www.goldengatebridge.org/>



Searching for Structures

Take a walk with your partner through your neighborhood, town, or community. How many of these architectural and engineering wonders can you discover?



construction site

gable



chimney



carved door



steeple

columns



arched door and windows



arch



cupola

flat roof



MAY THE FORCES BE WITH YOU

Structures remain standing because the forces of **tension** (pulling) and **compression** (pushing) are working together. If one of these forces is stronger than the other, the structure will fall. Feel these forces by trying the following activities with your partner.

Feel the **compression** or pushing force by trying this:



Feel the **tension** or pulling force by trying this:



Partner Challenge

The forces really are with you as you go about your daily activities. Think about what happens when you sit on the couch or pull on a door handle or pedal your bike.

What other examples of tension and compression can you and your partner discover in your daily routines?

BODY STRUCTURES

What types of structures can you “build” with your body? Try the following yoga poses with your partner. As you structure each pose, remember to move slowly and smoothly. Never stretch your muscles until they hurt. Be gentle. Try to hold each pose while you take 3 to 10 deep breaths. Breathe in and out through your nose.

Be a Tree

Stand with your feet firmly on the floor. Bend your right leg and place the heel high on the thigh of your left leg with your toes pointing down. Balancing on the left leg, press your palms together and raise your arms straight over your head. Stretch tall and graceful like a tree. Then switch sides. At the beginning you may feel more like a tree swaying in the wind, but keep practicing and your balance and strength will improve.



Can you guess where a tree or structure must be strongest to survive strong winds?

Be a Bridge



Lie on your back with your knees bent. Bring your heels close to your hips and grab your ankles. Press your feet firmly into the ground and then lift your chest and abdomen to form an arch or a bridge. Take several breaths, then come down and relax. Pull your knees to your chest for a moment or two.

Which parts of your body support the bridge structure?

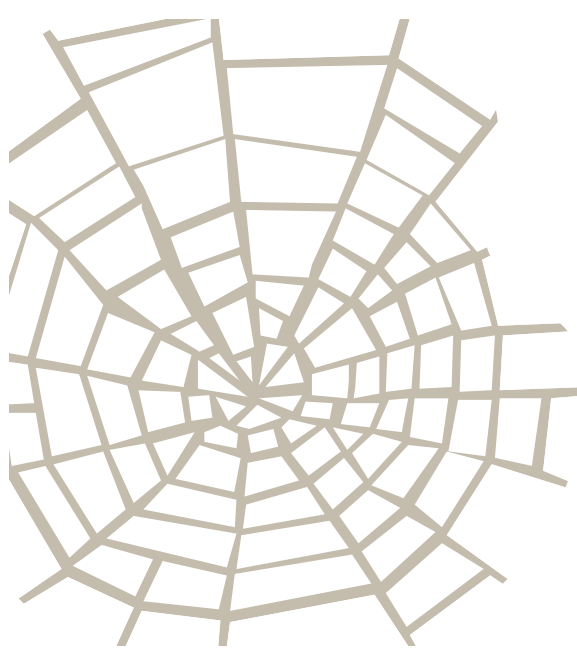
Be a Partner

Sit on the floor with your partner, facing each other. Bend your knees and keep your feet together and flat on the floor. Have your partner sit with her legs straight, pressing the soles of her feet lightly against the top of your ankles, with her toes pointed straight up. Now grab each other's wrists. Keeping your back very straight, lean forward as you push your partner away from you. Your partner, also keeping her back straight, leans back away from your pushing until you feel a gentle stretch. Then switch so that your legs are straight and your partner's knees are bent.



What structures are you reminded of as you feel the forces of tension (pulling) and compression (pushing)?

AMAZING ANIMAL ARCHITECTS



Did you know

The web of an **Orb-Weaving Spider** is so strong and stretchy that it could stop a jet plane in mid-flight if it were big enough!

Some birds, such as the **Social Weaver Birds** in Africa, use a variety of stitches and knots to weave their nests!

Beavers use trees, branches, mud, and stones to make dams and the lodges where they raise their young, eat, store food, and sleep!

Some **termites** found in Australia and Africa build nests of soil that can reach 20 feet high! One million termites can live in these structures.

Structural Match-Up

Here's a fun way of comparing animal structures to human ones.

Draw a line between each human structure in the left column and the animal structure in the right column that most closely resembles it.

1. Suspension bridge



2. Skyscraper



3. Log cabin



4. Apartment complex



A. Termite mound



B. Social Weaver Bird nest



C. Spider triangle web



D. Beaver lodge

Marshmallow Magic

A Game of Structures for 2 to 4 players.

Object

To be the first player to build a unique stable structure by using all the marshmallows and toothpicks picked up during the course of the game.

You will need

- ◆ One bag of miniature marshmallows
- ◆ One box of toothpicks
- ◆ Two pennies
- ◆ Four magic markers (different colors)
- ◆ Marshmallow Magic game board (on separate sheet)

Rules

1. Each player makes her game piece by coloring one end of a marshmallow with a marker of her favorite color.
2. Each player then takes three marshmallows and three toothpicks and makes her own triangle.
3. Determine who moves first by flipping the two pennies. **The person with the highest number of moves starts the game.** Score the pennies as follows:

both heads = move three spaces

both tails = move two spaces

one head and one tail = move one space

4. Take turns flipping the two pennies and moving the correct number of spaces. **Do whatever the space on the board indicates.**
5. To win, a player must land exactly on the FINISH space with a stable structure. **A structure is considered stable if it holds its shape when you gently press down upon it.**
6. Players can only build on their structures during their turn. All marshmallows and toothpicks collected throughout the game must be used to build the structure.

Marshmallow Magic Game

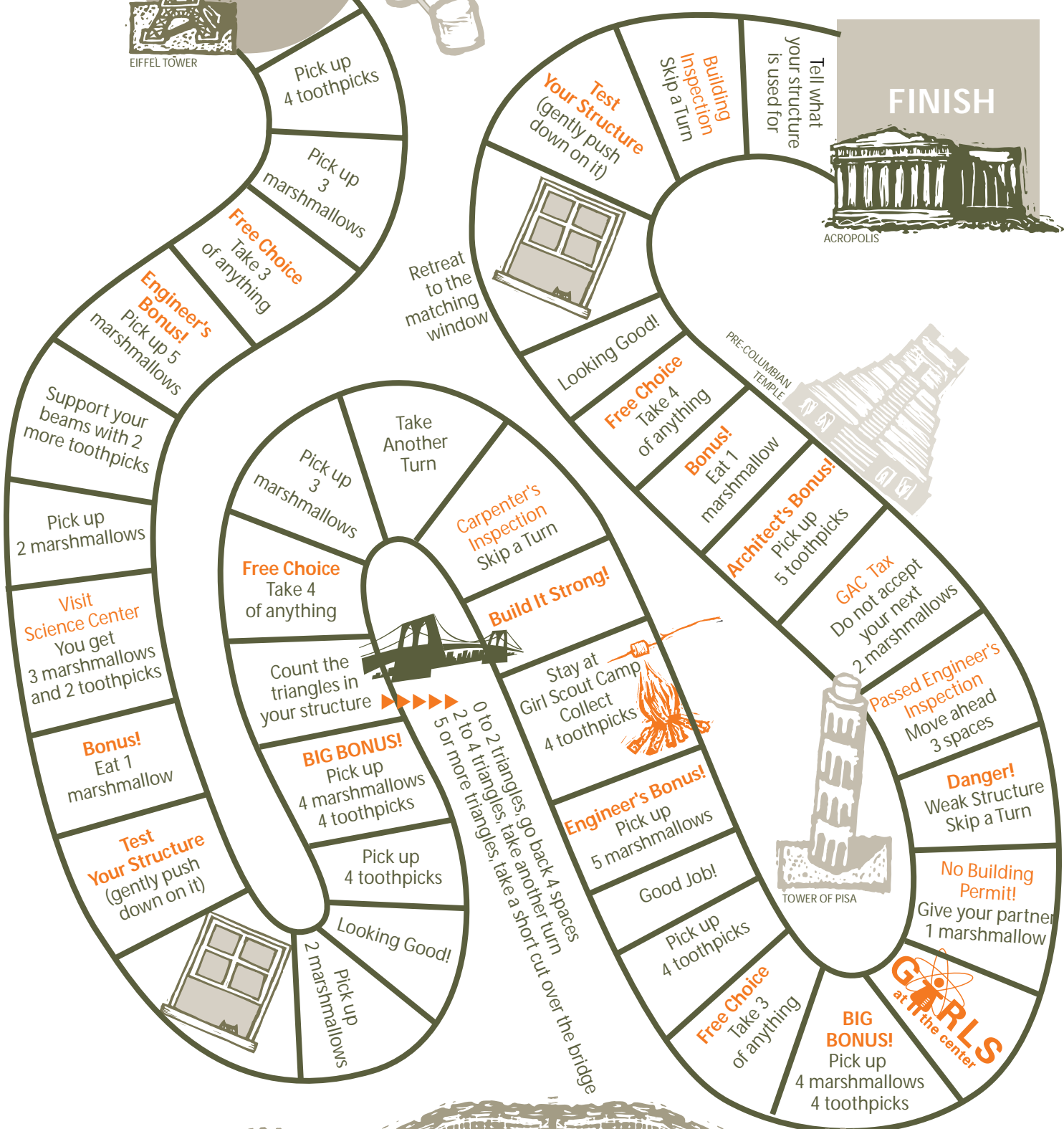


START

EIFFEL TOWER

FINISH

ACROPOLIS



GREAT WALL OF CHINA



Building Careers



Can you and your partner match the description of the job to the career?

Career

1. Architect
2. Building inspector
3. Computer design engineer
4. Construction supervisor
5. City planner
6. Civil engineer
7. Aerospace engineer
8. Landscape architect
9. Environmental designer
10. Structural engineer

Job Description

- A. Uses a computer to draw diagrams created in the design of buildings
- B. Designs dams, bridges, and roadways
- C. Plans and designs neighborhoods, towns and cities
- D. Specializes in eco-systems and the impact of development on the environment
- E. Oversees the construction activities of large building projects
- F. Creates buildings and designs spaces
- G. Designs ski areas, golf courses, and the grounds around buildings
- H. Designs the frameworks of buildings to resist earthquakes, winds, and gravity
- I. Checks structures to ensure that they meet safety standards
- J. Designs spacecraft



Answers: (1) F; (2) I; (3) A; (4) E; (5) C; (6) B; (7) J; (8) D; (9) G; (10) H

WOMEN IN SCIENCE

What Is a Civil Engineer?

Are your local bridges or roadways under repair? Is the airport in your area expanding? Is there a housing development under construction nearby? If so, civil engineers have been hard at work. A civil engineer plans, designs, constructs, and maintains roads, bridges, dams, airports, power plants, and other public systems. Civil engineers may specialize in building structure, water resources, soil and foundation, transport, town planning or construction. Civil engineers study math, science, design, and computer programming. A very important part of their job is making sure that their projects can “stand up” to natural disasters including wind, earthquakes, fire, and floods!

Next time you are driving over a bridge or through a tunnel or are visiting one of the world’s tall buildings, think about the science behind the construction.

Meet Mariagrazia Bruschi, civil engineer and bridge builder. She finds and fixes problems in bridges that are already built. Math and science are a very important part of her work. She uses her calculator and computer to test and check her designs. Safety is also important. She relies on safety gear when climbing around on bridges.

Mariagrazia became interested in bridge building thanks to her father, who encouraged her creative activities. He’s an engineer, too! The first bridge she ever built was for her puppets when she was a young girl. Although she enjoyed math in school, Mariagrazia did not like taking tests. But she studied hard and did her best.

Mariagrazia went to school for six years to get her master’s degree, and she now teaches bridge building at a university. Her dream is to be a project manager for a very long suspension or cable bridge.