

Designing Like a Spider



Design and build a spider web, which is just tight enough. Toss Velcro “spider” ping-pong balls at the web to measure effectiveness.

Engineering Design Process Outline

Step 1: Introduction

Step 2: Design Challenge

Step 3: Specifications and Constraints

Step 4: Design Criteria

Step 5: Develop Knowledge

Step 6: Self Quiz

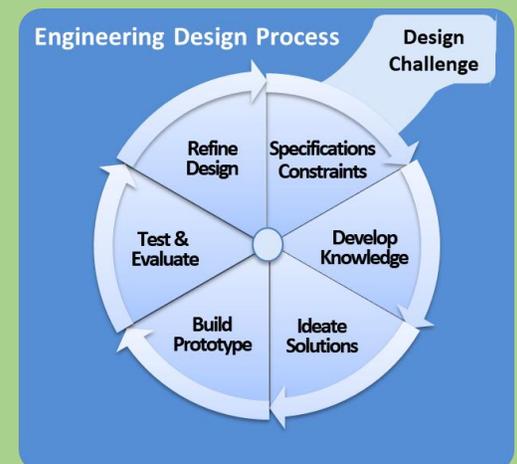
Step 7a: Create Your Frames

Step 7b: Create Your Webs and Bugs

Step 8: Test and Evaluate Prototype

Step 9: Reflection

Step 11: Design Solution



Step 1: Introduction

Spiders are one of the world's misunderstood little critters. While some humans find these eight-legged creatures frightening, but spiders are one of nature's skillful engineers, gifted with instinct and material that allows them to build strong and functional webs.

You will be acting as a natural mathematician to create a spider's web!

In nature, math shows up everywhere - from the natural occurring shapes in trees, flowers, bird's nests and of course spider webs. These shapes allow for animals and bugs to survive. Use geometry as your guide when you need to catch your flies!



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Step 2: Design Challenge

You and a teammate will be designing your very own spider web. The purpose of a spider's web is to catch flying insects, food. The flying insect you will catch is Velcro ping-pong ball. If the web is too tight, the ball may bounce off, if it is too loose the ball will go through it. Your web can be any design, but it must be able to catch "flies".

Spiders are very efficient creatures, so they use as little material as possible to achieve the food-capturing objective. Your challenge is to do the same. Be aware, the more yarn you use, the more the web will cost and one of your challenges is to minimize the cost.

Materials

For the flies:

- 3 Ping Pong balls
- Velcro tape or dots
- optional: googly eyes

For the web:

- Two 24-inch strips of one-inch wide cardboard*
- Yarn (1 yard to begin with)
- Liquid glue or glue gun (liquid glue takes longer to dry)
- 12 inches Duct tape
- 1 Index card or a piece of card stock (for frame re-enforcement)
- Scissors

* Cut strips from a recycled box, a poster board or foam board

Step 3: Specifications and Constraints

To create a spider web, we must first identify the specifications and constraints.

Specifications are what your solution must do. They are the requirements.

Constraints are things that limit your solution. Check off your answers below.

| | SPECIFICATION | CONSTRAINT |
|--|--------------------------|--------------------------|
| Limited time | <input type="checkbox"/> | <input type="checkbox"/> |
| Make a web that catches 3 Velcro "flies" | <input type="checkbox"/> | <input type="checkbox"/> |
| Limited materials | <input type="checkbox"/> | <input type="checkbox"/> |
| Minimize cost | <input type="checkbox"/> | <input type="checkbox"/> |

Step 4: Design Criteria

Your final product should deliver on the design criteria outlined below.

| Criteria | One | Two | Three |
|---------------------------------|--------------------|-------------------------|--------------------|
| Cost of Yarn, 10 cents per yard | More than 60 Cents | Between 40 and 60 Cents | Less than 40 Cents |
| Ping Pong Balls Captured | None | One or two | Three |

Step 5: Develop Knowledge - How Spiders Build their Webs

Spiders are legendary builders of the animal kingdom. They can produce as many as seven different kinds of silk. To begin a web, a spider anchors a strand of dragline silk—three times stronger than the Kevlar in bulletproof vests—and waits for a breeze to blow it to a second attachment point. The arachnid then completes the outer ring and spokes, and finally builds the spiral. A spider will create sticky and non-sticky threads. Sticky threads are used around the outer spiral to catch prey.

Webs allow a spider to catch prey without having to expend energy by chasing and catching it. Thus, it is an efficient method of gathering food. However, constructing the web requires a large amount of energy to produce the protein required to make the silk. After a time, the silk will lose its stickiness and become inefficient at capturing prey. In which case, it is common for spiders to eat their own web daily to recoup some of the energy used in spinning. The silk proteins are then recycled.

Here are pictures of different spider webs.



Step 6: Self-Test

Based on your knowledge, answer these questions.

1. Webs are an efficient method of gathering food.

- True
- False

2. What is required to produce silk?

- Sugar
- Yarn
- Protein

3. Spiders can consume their webs to regain energy.

- True
- False

Step 7a: Create Your Frames

Make a sketch of your frame and web design on a piece of paper. What shape will you use for your frame? How will you weave your web?

When creating the frame be sure to use all of your framing materials.

Cardboard is a very strong material, so once you have decided on the shape of your frame, cut the sides. Double-up the thickness by gluing pieces together. White glue can be used, but it takes a while to dry; glue from a glue gun is faster—and hot, so be careful using it.

You will want to join the frame together; at each corner use a strip of file card, light weight card stock, to join the pieces. You will see these in the picture below. Attach the index card on both sides to create a rigid, inexpensive frame.



Step 7b: Create your Webs and Bugs

Once you have decided on the shape of your frame and built it, use your web design drawing to build your web. Strands of yarn should be attached to the frame using duct tape. Knots or tape can be used to connect yarn pieces inside the frame.

Remember, you are smarter than a spider! Use your knowledge of geometry and consider the size of the ping pong ball as you design and build your web.

To Create Your Insects

You will have 3 ping pong balls, a roll of Velcro tape (or a package of Velcro dots), scissors and optional googly eyes.

If you have the dots, place them around the ball. If you have the tape, cut two strips of tape that wrap around the ball.

And for fun, add googly eyes to bring your bugs to life!

Step 8: Test and Evaluate

Support the frame horizontally on two chairs and then drop all three Ping Pong Ball Insects at once from a height 3 feet above the frame. Good luck!

| Criteria | One | Two | Three |
|---------------------------------|--------------------|-------------------------|--------------------|
| Cost of Yarn, 10 cents per yard | More than 60 Cents | Between 40 and 60 Cents | Less than 40 Cents |
| Ping Pong Balls Captured | None | One or two | Three |

1. Final score

Step 9: Reflection

Having tested your web, it's time to think about what you would do differently next time!

What would you do to improve your design?

A large, empty rectangular box with a thin blue border, intended for the user to write their reflections on how to improve their design.

Step 10: Design Solution

Congratulations! You've learned about how a spider makes their web and used the knowledge to create your very own web! Well done nature mathematicians! Remember next time you see a spider's web, look at the cool shapes and designs they make to catch their food!

