Girls' Bill of Rights

Girls have the right to **BE THEMSELVES AND TO RESIST STEREOTYPES.**

Girls have the right to **EXPRESS THEMSELVES WITH CREATIVITY AND ENTHUSIASM.**

Girls have the right to **TAKE RISKS TO STRIVE FREELY AND TO TAKE PRIDE IN THEIR SUCCESS.**

Girls have the right to **ACCEPT AND APPRECIATE THEIR BODIES.**

Girls have the right to **HAVE CONFIDENCE IN THEMSELVES AND TO BE SAFE IN THE WORLD.**

Girls have the right to **PREPARE FOR INTERESTING WORK AND ECONOMIC INDEPENDENCE.**

STEM

UNITED STATES NAVAL ACADEMY

Take the Pledge

As a young woman, I pledge:

- To challenge myself in education and character.
- To meet those challenges with dignity and grace.
- To ask for help when I need it.
- To be curious and seek new opportunities.

Signature　　　　Date

Ask your parents to read and sign:

As a parent, I pledge:

- To encourage and support my daughter in her academic endeavors.
- To identify effective mentors for my daughter in her career and studies.
- To offer additional support for my daughter in her chosen field.
- To become better informed about the issues that face girls today.

Signature　　　　Date

Adapted from girlsinc.org

www.usna.edu/stem

Engineers & Scientists Make the World a Better Place

Engineers and scientists work on projects in many different topic areas. They tackle challenges in the environment, medicine, agriculture, fashion, media, and industry-solving problems and making improvements.

What kind of things are you interested in?

1. ______________________________
2. ______________________________
3. ______________________________

Engineers and scientists help people and make the world a better place. They work to keep the planet healthy, help people be better prepared for natural disasters, make sure people have enough to eat, help people stay healthy, make it easier for people to connect, and more. What would you work on if you were an engineer or scientist?

What kind of impact do you want to have on the world?

1. ______________________________
2. ______________________________
3. ______________________________

Engineers and scientists are creative and imaginative. They work in teams and collaborate with others. With curiosity and persistence, they work to make a difference. Communication skills, analytical abilities, and creativity are all important to make discoveries, design something better, and create things that matter.

What characteristics would you use to describe yourself? What are your strengths?

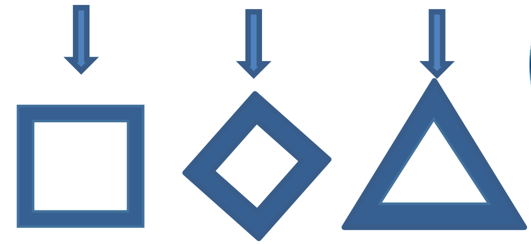
1. ______________________________
2. ______________________________
3. ______________________________

Love Triangle

1. **Drill** holes, large enough for a paper fastener, in each end of 7 craft sticks with each hole centered ½" from the end of the stick.
2. **Fasten** three sticks together to form a triangle.
3. **Fasten** the other four together to make a square.
4. **Measure** the diagonal length across the square.
5. **Cut** 1" balsa to the diagonal length.
6. **Drill** holes in the balsa for fasteners.
7. **Push** down on top of the square. Reshape and rotate to form a diamond, push down. Push the triangle – what happens to each shape?
8. **Add** the balsa as a diagonal brace to the square. What changes?

Triple Play

Frames for buildings and other structures appear to be repeating squares or rectangles, but closer inspection reveals that most of the rectangular shapes are braced with a cross member, actually dividing the shape into two triangles. Even geodesic domes (like soccer balls) may look like an arrangement of pentagons and hexagons, however, each of those shapes can also be divided into triangles. A Ferris wheel frame has triangular shapes as do towers, cranes, and jungle gyms. Triangles fit together to provide strength and stability since they have only three corners (connections) and three angles as compared to four for a square or rectangle. The angle between two sides of the triangle is based on the length of the opposite side of the triangle. According to geometric relationships, the angles are fixed, based on the relative length of sides. This is why a triangle cannot collapse!



UNITED STATES NAVAL ACADEMY

Feel the Force

When a load is applied to the corner of a triangle, the resulting **force** is directed to the sides rather than downward. The sides of the triangle are in either **compression** or **tension** with no bending. To demonstrate tension, have two students stand facing each other with enough distance between them that they can hold hands with straight arms. As they slowly lean away from each other, they will feel tension in their arms. For compression, have two students stand facing each other with enough distance between them that they can make an arch with their hands when their palms are touching. As they slowly lean in, they will feel compression in their arms.

NAVY NOTES

In the photo, Seabees from Naval Mobile Construction Battalions construct a bridge in Iraq to replace one that was destroyed during Operation Enduring Freedom. Construction of state-of-the-art bases and facilities all over the world are the responsibility of the Navy's construction engineers and workers. COURTESY OF U.S. NAVY.

Bionic Hand

1. **Trace** your hand onto cardstock and cut out.
2. **Cut** the fingers where your joints are.
3. **Tape** the hand back together leaving a space between each section.
4. **Cut** drinking straws into 38 pieces (~ ½" long).
5. **Glue** a straw piece vertically onto each section and onto the palm on both sides of the hand.
6. **Thread** a piece of string/ribbon through the straws for each finger.
7. **Tape** the string/ribbon at the top of your hand and leave it hanging at the bottom.
8. **Pull** the strings to curl and uncurl the fingers.

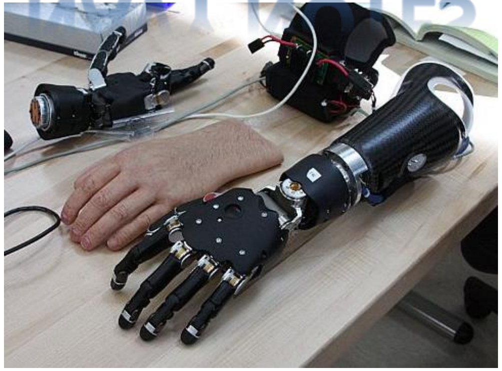
Strings Attached

The human hand is made up of 27 individual bones, and functions using 30 muscles and 3 main nerves. **Tendons** are the "strings" that help muscles move. They attach muscle to bone. **Ligaments** attach bone to bone and allow for structure and support. Hand and finger motions range from a power grip to precision movement.

Recommendations

- Glue the hand onto a piece of wood or painters stick to represent an arm.
- Glue small pieces of wood onto the palm below the straws to provide more support.

NAVY NOTES

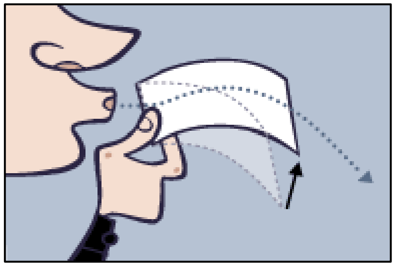


A new prosthetic arm created by Walter Reed National Military Medical Center is controlled by a wearer's brain and allows for independent control of the fingers.

UNITED STATES NAVAL ACADEMY

Paper Trail

1. **Cut** a piece of paper into a strip that is 3 inches wide and 8.5 inches long.
2. **Hold** an end of the strip just below your lips.
3. **Blow** a steady stream of air above the paper.
4. **What** happens to the paper when you blow?



Come Up for Air

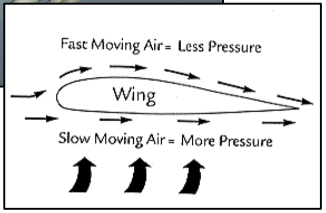
The moving airstream above the paper has slightly lower pressure than the static atmosphere below. The **static** air below the paper has a higher pressure and tends to move toward the area of low pressure. The paper is moved upward by the higher pressure static air.

Bundle of Energy

Bernoulli's principle states that an increase in the **velocity** of a stream of fluid results in a decrease in **pressure**. The principle can be derived from the principle of **conservation of energy**. In a steady flow, the sum of all forms of energy in a fluid along a streamline is the same at all points on that streamline.

NAVY NOTES

Airplane wings are shaped so that airflow is faster over the top of the wing and the air pressure is lower. Under the wing, the airflow is slower and the pressure is higher. This causes lift and higher pressure under the wing pushes the wing up. The Navy relies on its planes and jets to deter threats, obtain information, and get supplies.



http://quest.nasa.gov/aero/teachers/foa.html

Fibonacci Fish

1. One pair of fish is able to produce an additional pair each month, beginning at the age of 2 months.
2. Start with one pair of newborn fish.
3. Determine the number of pairs of fish present in the school each month for 6 months, assuming 0% mortality.
4. Look at your results and determine the pattern.

The **Fibonacci sequence** is an infinite sequence whose current term is determined recursively by summing the previous two terms. The ratio of consecutive terms in the Fibonacci Sequence approach the **Golden Ratio, $\phi \approx \mathbf{1.618}$** … The Fibonacci Sequence is prevalent in biological settings, such as the number of spirals on a pineapple, phyllotactic arrangement of leaves on a plant and ancestry of the X and Y chromosomes. Additionally, the extension of the Fibonacci Sequence to the Golden Ratio, the **Golden Rectangle**, the **Golden Spiral** and the **Golden Angle** creates an ubiquitous presence in art (musical harmonies), engineering (architecture), weather (hurricanes), and spiral growth (optimal angle for uniform cell packing).

Scientific Information

Leonardo Fibonacci is credited with introducing the Arabic number system (with digits 0-9, and place values) to Western Civilization. An example from his *Book of Calculation* was the generation of the infinite sequence of numbers that bears his name, the Fibonacci Sequence: {1,1,2,3,5,8,13,21,34,…}. The recursive formula for the generation of subsequent terms is: $x_n = x_{n-1} + x_{n-2}$, where n is the term number in the sequence. Because the recursive formula requires the previous 2 inputs, "initial conditions" of $x_1 = 1$ and $x_2 = 1$ are provided along with it. Although there are multiple mathematical representations for the terms of the Fibonacci's sequence, Binet's formula gives a closed-form method of calculating any Fibonacci term: $x_n = \frac{\phi^n - (-\phi)^{-n}}{\sqrt{5}}$, where $\phi = \frac{1+\sqrt{5}}{2}$ is the exact representation of the Golden Ratio.

NAVY NOTES

Navy Applications

Generating random numbers is often a first step in cryptographic methodologies that employ complicated mathematics, usually involving large prime numbers. Since random numbers generated by computer algorithms are not truly random, but are instead determined by a "seed," the algorithms that produce them are called pseudorandom number generators. Some of these PRNGs use Fibonacci numbers in their algorithms.

Fibonacci Fish

How many pairs of fish are produced in 6 months if one pair of fish produces one additional pair per month, starting at 2 months of age?

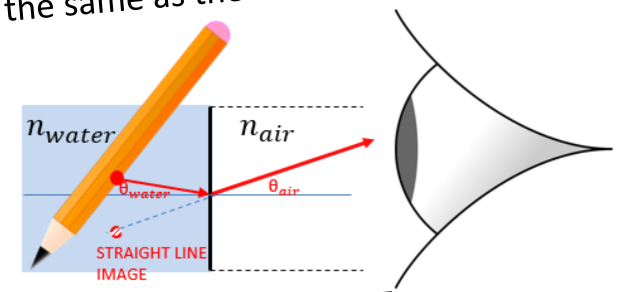
Start with a single pair of newborn fish in Month 0 and assume 0% mortality.

FISHY WORKSPACE	time (month)	Pairs of fish
0 months old	0	1
1 month old	1	
2 months old	2	
3 months old	3	
4 months old	4	
5 months old	5	
6 months old	6	

Look at the total number of fish pairs each month. Do you see a pattern?

Bending Pencils

1. **Fill** a clear glass halfway with water.
2. **Fill** another clear glass halfway with oil.
3. **Place** a pencil in each glass.
4. **Observe** the pencil in each container. Does the pencil in water look the same as the one in the oil?



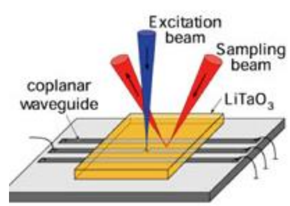
The pencil and your brain

Snell's Law describes the relationship between the refractive indices and the angles of incidence and refraction at the boundary between two media: $n_1 sin\theta_1 = n_2 sin\theta_2$. You see the pencil as light rays reflect off it and travel to your eyes. This means that the light originates in the water and then passes through an interface before entering the air on its way to your eyes. The light waves pass from a medium of higher refractive index ($n_{water} = 1.33$) to a medium of lower refractive index ($n_{air} = 1$). Therefore, the light waves bend away from the normal at the interface, which is why the part of the pencil in the water appears wider. Since the angle of refraction is related to the ratio of the sines of the angles of incidence and refraction relative to normal, this effect is more pronounced when the angle of incidence is closer to the normal. The brain assumes that light travels in a straight line, so the part of the pencil that is submerged appears to be offset from the part of the pencil that is above the water line. The overall effect is an enlarged offset image resting at the same angle as the original.

Refraction of Light

Electromagnetic waves travel in a straight line through a medium. When light passes an interface between two media, it bends and changes direction. The refractive index of a material, *n*, is the ratio of the speed of light in air (*c*) to the speed of light in that material (*v*), $n = \frac{c}{v}$. When this equation is applied to water, which has a refractive index of 1.33, it means that light travels through water at three-fourths the speed it travels through air. The refractive index determines how much the incident angle (relative to normal) bends at the interface to form the refracted angle. The refracted angle moves closer to the normal when the light ray passes into a medium with a higher refractive index.

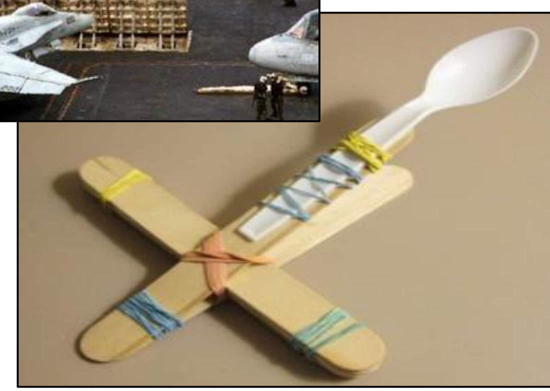
NAVY NOTES



The ONR Electromagnetic Materials Program seeks to dominate the electromagnetic spectrum and improve the performance of electronic and photonic devices for Navy applications. The current emphasis is on phase-change materials that switch between high and low resistive states, with a corresponding change in the refractive index, opening opportunities in optical devices (modulators, switches, filters, etc.) that can be tuned.

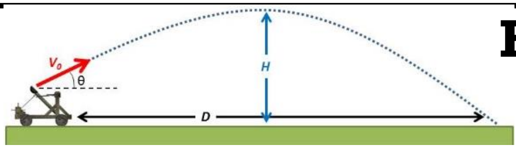
Engineering Design Challenge: Catapulting Math

A **catapult** is a device used to launch a **projectile** without explosives or propellants. While previously used in medieval warfare, catapults are used today to launch airplanes on Navy aircraft carriers. The runway on a ship is much shorter than the runways found at airports, and as a result, a catapulting mechanism is required in order for an airplane to generate lift. Catapults help planes reach these high speeds in a short distance.



For this challenge, construct a simple spoon catapult using popsicle sticks, rubber bands, and a spoon. Take preliminary measurements to determine how far and high your projectile travels. Use given supplies to modify your design to improve distance traveled by the projectile. Collect data from each trial to determine what variables need to be adjusted in order to improve distance. You will optimize your catapult's performance at the best launch angle measured in degrees.

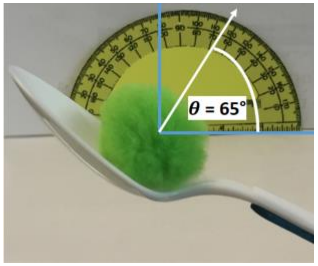
www.usna.edu/stem



Engineering Design Challenge: Catapulting Math

Construct the simple spoon catapult and record your projectile angle. Calculate the average angle over three trials:

Trial	Observed θ
1	
2	
3	
AVG =	



Example:
Launch the projectile a few times while someone holds the protractor behind it. Note the angle at which the projectile passes in front of the protractor. Try to pull the spoon back the same amount every time.

Launch your projectile three more times, as consistently as you can, maintaining the average launch angle. Monitor and record the maximum height and distance traveled in inches by the projectile:

Trial	Max Height	Max Distance	Calculated θ	$\Delta\theta$
1				
2				
3				

Determine the launch angle for each trial using the formula below:

$$\text{Calculated } \theta = \tan^{-1}\left(\frac{4H}{D}\right)$$

Calculate the difference between your observed angle and your calculated angle:

$$\Delta\theta = |\text{average observed angle } - \text{calculated angle}|$$

Improve your catapult using the given supplies. Repeat these data steps until you have an *optimized design* that produces a projectile launched to maximum distance. Also, create a design that has a *reproducible* launch angle (low and consistent $\Delta\theta$). Keep in mind that launch angle is a function of projectile height and distance!

Mars Landing

You have been tasked with designing effective landing equipment for the upcoming mission to Mars. Your task is to design and build, on time and on budget, a **Mars landing device**. This mission's goal is to send two astronauts to Mars in order to study our neighboring planet. In order for this mission to be a success, the spacecraft *and* those aboard must land safely.

Your mission is to design and build spacecraft landing equipment that can:

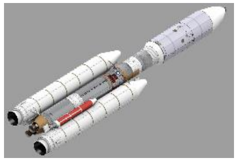
- Successfully land after a 2.5 ft drop while keeping the passengers (ping pong balls) safely on board.
- Be constructed within your 45 minute build time.
- Cost less than **$200 million**.

Exceeding this will disqualify your team for launch. Note the market value for each of the available materials.

Material	Cost	Material	Cost
Straws (clear)	$3 million	Plastic bags (small)	$5 million
Straws (red)	$6 million	Plastic bags (large)	$10 million
Balloon (standard)	$20 million	Popsicle stick (small)	$500k
Pipe cleaner	$4 million	Popsicle stick (large)	$1 million
½ Sheet of Paper	$5 million	Rubber Bands	$2 million
Hot dog boat	$7 million	Plate	$10 million
6 inches of masking tape	$7 million	Cup	$15 million
6 inches of duct tape	$10 million	6 inches of string	$3 million
Cotton balls (small)	$500k	Zip ties	$3 million
Cotton balls (large)	$1 million	Spoon	$5 million

DEFENSE NOTES

The Viking 1 and 2 missions to Mars were launched on Titan III-E rockets. The Titan III program was developed by the U.S. Air Force with the first launch in 1959 and continued on for 50 years. The Titan III-E specifically included a Centaur upper stage. Beyond the Viking missions, Titan-Centaur rockets were used to launch the successful Voyager space probes which have been traveling for over 40 years and farther than any other spacecraft to date.



Mars Landing

Engineering Design Rubric

Criteria	Fully Met (2 pts)	Partially Met (1 pt)	Did Not Meet (0 pts)
Landing gear survives 2.5 ft drop without losing any passengers			
Landing gear survives 2.5 ft drop without tipping over			
Creative use of materials			
Innovative design			
Demonstration of teamwork			
Expense	Under Budget	At Budget	Over Budget

Variations:

This activity can be modified to provide an even greater challenge for older students. Suggestions:

- Require design drawings, risk assessment and budget prior to authorizing build.
- Reduce time and/or budget.

For younger students, marshmallows can be used for astronauts to make it easier for them to remain inside the cup. A larger cup could also be used.

Learn more:
https://mars.nasa.gov/programmissions/missions/past/viking/

Resources:
http://pbskids.org/designsquad/build/touchdown/