THE ENGINEERING PLACE

North Carolina State University
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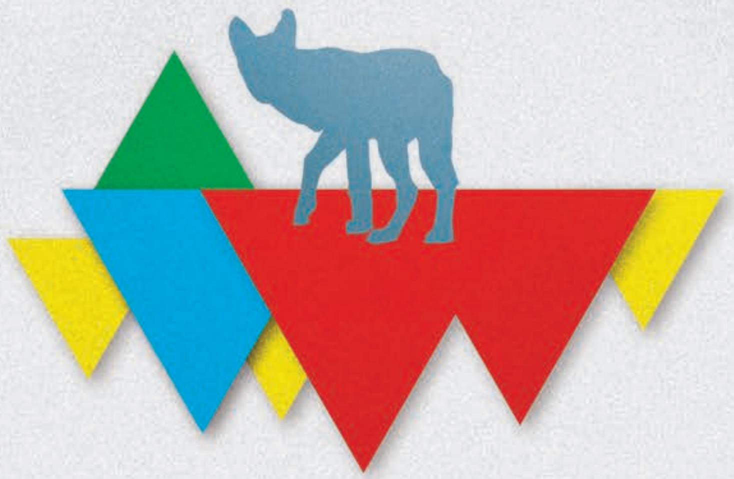
www.engr.ncsu.edu/theengineeringplace

NC STATE UNIVERSITY
125 YEARS
College of Engineering

THE ENGINEERING PLACE

Activity Journal

Raleigh Elementary Camp I



Welcome!

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What are the Engineering Summer Programs?

The Engineering Summer Programs at NC State are a great way to learn what engineering is all about and to have fun while doing it! Our program activities allow you to design, create, and build, just like an engineer. Our goal is to expose students to the many different types of engineering and to show how engineers impact the world around us.

We offer the following programs for K-12 students:

Elementary School Day Camps
Rising 3rd through 5th grade students

Middle School Day Camps
Rising 6th through 8th grade students

High School Day Camps
Rising 9th and 10th grade students

High School Residential Camps
Rising 11th and 12th grade students

Visit the our website for additional information:
www.engr.ncsu.edu/theengineeringplace

Mission Statement

To provide an enlightening, educational, hands-on experience for elementary and middle school students and teachers that introduces, broadens perspectives, and enhances experiences in the disciplines of engineering.

To attract a diverse population to the field of engineering by providing initial or reinforcing positive experiences to all populations.

Expectations for Participants

- Respect staff, materials, and other participants through your words and actions.
- Use materials responsibly and with conservation… engineers are always reducing costs!
- Clean up after yourself.
- Think “outside the box” and don't be afraid to ask questions!
- Try things that might not work… experience is the highway to success!

Partnering Engineering Camp Locations

Rocky Mount (Gateway Technology Center at Wesleyan College)
(1) Elementary, (1) Middle, and (1) High School Day Camp

Hickory (NC Center for Engineering Technologies)
(2) Elementary, (1) Middle, and (1) Middle School Robotics Camp

Havelock (Craven Community College)
(1) Middle School Camp

Raleigh Elementary Camp Staff

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Program Coordinators

Susan D'Amico – Coordinator, Engineering Summer Programs
B.S. Industrial Engineering, NC State University

Lindsey Smith Genut – Coordinator, The Engineering Place
B.S. Engineering Mechanics, Columbia University
M.C.E Civil Engineering, Johns Hopkins University

Rachel Chapla – Assistant Coordinator, Engineering Summer Programs
Textile Engineering Undergraduate, NC State University

Teachers

Taryn Griffin	Hilburn Academy
Darell Grimes	Wellcome Middle School
Dave Jones	Brentwood Elementary School
Meg Osterhoff	York Elementary School
Cindy Raynor	River Dell Elementary School
Marciava Stovall	West Hoke Middle School

NC State Undergraduate Staff

Amber Williams	Industrial and Systems Engineering
Andie Aldana	Computer Science
Natalie Bryan	Electrical and Computer Engineering
Jacob Reedy	Aerospace and Mechanical Engineering
David Shang	Electrical and Computer Engineering
Kevin Heyer	Chemical and Biomolecular Engineering

High School Staff

David D'Amico	Cary High School
Kayla Wise	West Johnston High School
Jackie Yeh	Green Hope High School
Alex Mizak	Green Hope High School

High School Volunteer Assistants

Andy Yeh	Green Hope High School
Lauren Mirra	Cary High School
Veronica Lavelle	Cardinal Gibbons High School
Emma Gearon	Lexington Catholic High School
Joe Gearon	Hodgenville High School

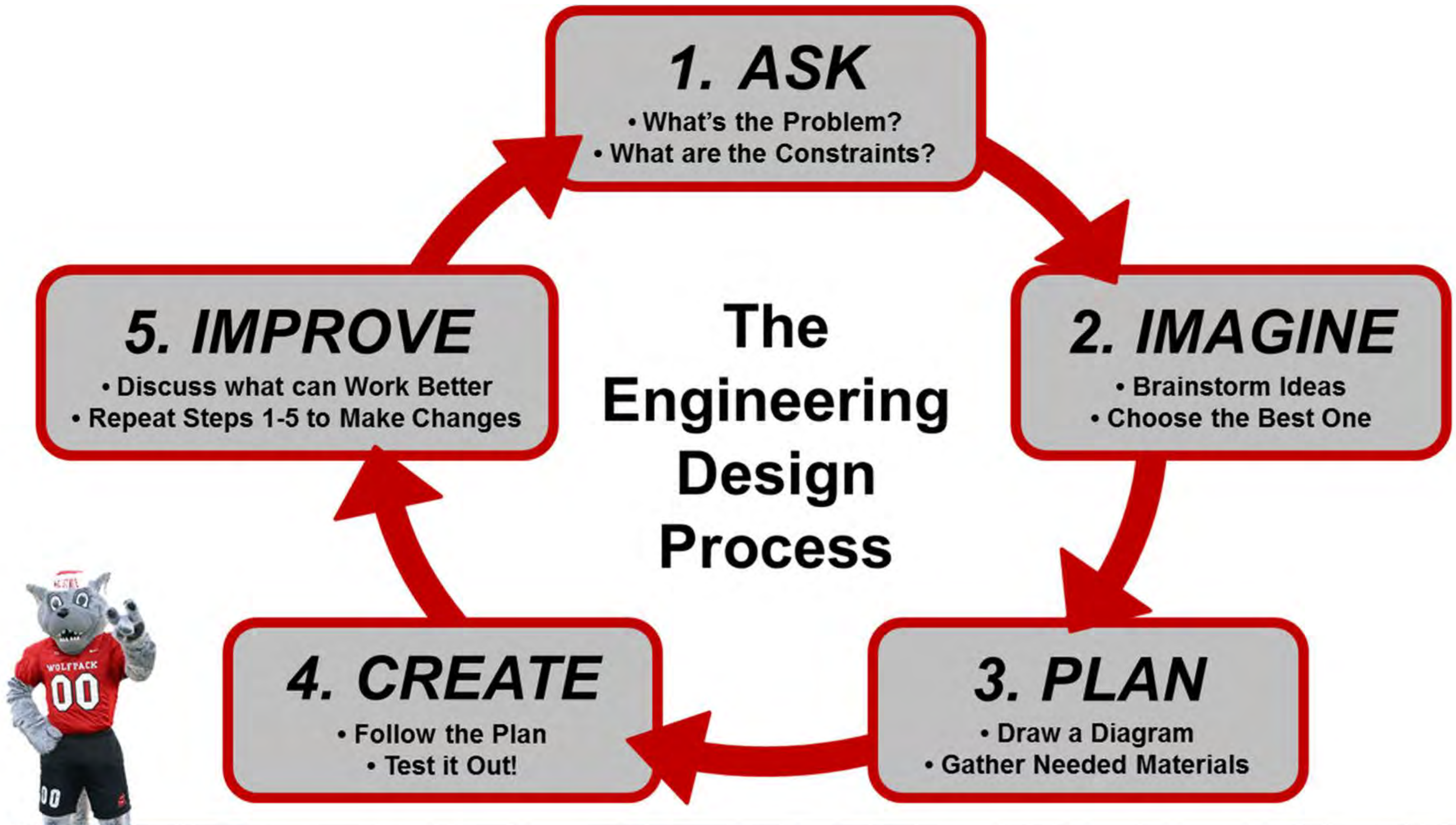
What is an Engineer?

Engineers use science and math to design and create solutions to the world's problems. They design materials, structures, machines, and systems, while considering the limitations imposed by practicality, safety, and cost.

Engineering at NC State

The College of Engineering at NC State is comprised of 12 departments offering 18 Bachelors, 17 Masters, and 13 Ph.D. degree programs:

- Biological and Agricultural Engineering
- Biomedical Engineering
- Chemical and Biomolecular Engineering
- Civil, Construction, and Environmental Engineering
- Computer Science
- Industrial and Systems Engineering
- Electrical and Computer Engineering
- Materials Science and Engineering
- Mechanical and Aerospace Engineering
- Nuclear Engineering
- Paper Science and Engineering
- Textile Engineering



- The Engineering Design Process is a series of steps that lead to the development of a *new* *product* or *system*.
- You may start at ANY step of the process.
- After you improve your design once, you can begin the Engineering Design Process all over again to <u>refine your technology</u> … or you may want to focus on a <u>single step</u>.

Design process adapted from the Museum of Science Boston "Engineering Is Elementary" program.

Agenda

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Time	Student Activity	Location	Group Size	Engineering Field of Study
MONDAY June 18th				
8:30 - 8:45 8:45 - 9:00	Check-In	SAS Hall	All	
9:00 - 9:15	Team Assignments/Badges/Journals/ Pre-survey/ Draw an Engineer	Boardroom	All	
9:15 - 9:30 9:30 - 9:45 9:45 - 10:00	Welcome/ Intros/ Overview/ Rules and Expectations/ Engineering Suitcase	Boardroom	All	Overview of All
10:00 - 10:15 10:15 - 10:30	Team Warm-up Activity	Warm-up Locations	TBD	All
10:30 - 10:45 10:45 - 11:00 11:00 - 11:15	Activity: Marshmallow Challenge	Breakout Rooms	Groups of 2 - 3	Civil
11:15 - 11:30 11:30 - 11:45 11:45 - 12:00 12:00 - 12:15 12:15 - 12:30	Lunch - Marco's Pizza/ Engineering Your Team Activity	Boardroom		
12:30 - 12:45 12:45 - 1:00 1:00 - 1:15 1:15 - 1:30 1:30 - 1:45 1:45 - 2:00	Activity: Pasta Bridges	Breakout Rooms	Groups of 2 - 3	Civil
2:00 - 2:15 2:15 - 2:30 2:30 - 2:45	Activity: Self Folding Shapes	Breakout Rooms	Groups of 2 - 3	Chemical/ Materials
2:45 - 3:00 3:00 - 3:15	Competitions: Pasta Bridges	Boardroom		
3:15 - 3:30	Dismissal	Boardroom		
TUESDAY June 19th				
9:00 - 9:15 9:15 - 9:30 9:30 - 9:45 9:45 - 10:00 10:00 - 10:15	Activity: Puff Mobiles	Breakout Rooms	Groups of 2 - 3	Mechanical
10:15 - 10:30 10:30 - 10:45 10:45 - 11:00 11:00 - 11:15 11:15 - 11:30	Activity: Water Rockets	Breakout Rooms/ Court of Carolina	Groups of 2 - 3	Aerospace
11:30 - 11:45 11:45 - 12:00 12:00 - 12:15 12:15 - 12:30	Lunch - Chick-fil-A	Boardroom		
12:30 - 12:45 12:45 - 1:00 1:00 - 1:15 1:15 - 1:30 1:30 - 1:45 1:45 - 2:00 2:00 - 2:15 2:15 - 2:30 2:30 - 2:45	Activity: Create a Critter	Breakout Rooms	All	Mechanical
2:45 - 3:00 3:00 - 3:15	Exhibitions: Create a Critter	Boardroom		
3:15 - 3:30	Dismissal	Boardroom		

nc state ENGINEERING

Agenda

Time	Student Activity	Location	Group Size	Engineering Field of Study
WEDNESDAY June 20th				
9:00 - 9:15	Activity: Nuclear Engineering Presentation (Dr. Amy Orders)/ Radiation Scavenger Hunt	341/ TBD	All/2	Nuclear
9:15 - 9:30				
9:30 - 9:45				
9:45 - 10:00				
10:00 - 10:15				
10:15 - 10:30	Activity: Nuclear Engineering Presentation (Dr. Amy Orders)/ Radiation Scaveger Hunt	341/TBD	All/2	Nuclear
10:30 - 10:45				
10:45 - 11:00				
11:00 - 11:15				
11:15 - 11:30				
11:30 - 11:45	Lunch - Moe's Southwest Grill	Boardroom		
11:45 - 12:00				
12:00 - 12:15				
12:15 - 12:30				
12:30 - 12:45	Field Trip: Textiles Engineering Building Centennial Campus	Breakout Rooms	Half the groups on each tour	Textile
12:45 - 1:00				
1:00 - 1:15				
1:15 - 1:30				
1:30 - 1:45				
1:45 - 2:00				
2:00 - 2:15				
2:15 - 2:30				
2:30 - 2:45				
2:45 - 3:00				
3:00 - 3:15				
3:15 - 3:30	Reminders/ Dismissal	Boardroom	All	
THURSDAY June 21st				
9:00 - 9:15	Activity: Engineering World Health/ Egg Crash Gravity Cars	341/ Breakout Rooms	EWH: Teams 1/3/5 Egg CGC: Teams 2/4/6 Groups of 2 - 3	Biomed/ Mechanical
9:15 - 9:30				
9:30 - 9:45				
9:45 - 10:00				
10:00 - 10:15				
10:15 - 10:30				
10:30 - 10:45				
10:45 - 11:00				
11:00 - 11:15				
11:15 - 11:30	Lunch at Clark Dining Hall	Clark Dining Hall		
11:30 - 11:45				
11:45 - 12:00				
12:00 - 12:15				
12:15 - 12:30				
12:30 - 12:45	Engineering World Health/ Egg Crash Gravity Cars	341/ Breakout Rooms	EWH: Teams 2/4/6 Egg CGC: Teams 1/3/5 Groups of 2 - 3	Biomed/ Mechanical
12:45 - 1:00				
1:00 - 1:15				
1:15 - 1:30				
1:30 - 1:45				
1:45 - 2:00				
2:00 - 2:15				
2:15 - 2:30				
2:30 - 2:45				
2:45 - 3:00	Competitions/Awards: Gravity Cars	Boardroom		
3:00 - 3:15				
3:15 - 3:30	Dismissal	Boardroom	All	

Agenda

Time	Student Activity	Location	Group Size	Engineering Field of Study
FRIDAY June 22nd				
9:00 - 9:15	**Activity - Prepare for Competitions/ Exhibitions** **Re-engineer any of the week's activities.**	**Breakout Rooms**	**Group**	
9:15 - 9:30				
9:30 - 9:45				
9:45 - 10:00				
10:00 - 10:15				
10:15 - 10:30				
10:30 - 10:45				
10:45 - 11:00				
11:00 - 11:15				
11:15 - 11:30				
11:30 - 11:45	**Lunch - Village Deli/ Engineering Your Team Activity**	**Boardroom**		
11:45 - 12:00				
12:00 - 12:15				
12:15 - 12:30				
12:30 - 12:45				
12:45 - 1:00	**Reminders/ Post Survey/ Closing Remarks/ Re-Draw an Engineer/ Clean-up**	**Boardroom**		
1:00 - 1:15				
1:15 - 1:30				
1:30 - 2:00	**Travel to Competition Venue**			
2:00 - 2:45	**Presentation to Parents**	**Withers 232A**		
	Exhibition & Competitions			
	Challenge I - Egg Crash Cars	**Court of Carolinas**	**All**	
2:45 - 3:00	**Challenge II - Water Rockets**	**Court of Carolinas**	**All**	
3:00 - 3:15	**Exhibition - Self Folding Shapes, Create a Critter, Sailboats, Puff Mobiles, Pasta Bridges**	**Daniels Hall**	**All**	
3:15 - 3:30	**Awards, Closing & Dismissal**		**All**	

Draw an Engineer

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Objective: In the space below, draw what you imagine an engineer looks like.

Marshmallow Challenge

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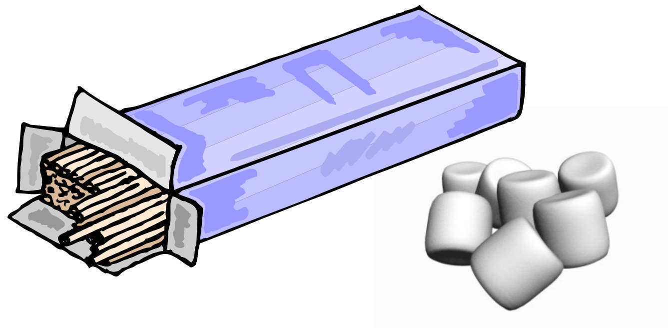
Objective: To build the tallest tower possible out of uncooked spaghetti noodles that can hold a large marshmallow on top.

Materials:
- 20 pieces of spaghetti
- 1 arm's length of masking tape
- 1 meter of string
- 1 large marshmallow



Activity Details: You will have 20 minutes to build the tallest free-standing tower with a marshmallow on top. You may not touch the tower after 20 minutes, and it cannot be taped to the table or floor. The marshmallow can have pasta pieces stuck into it.

Test Process: The height of the tower will be measured in inches from the surface it is resting on to the highest point on the tower. If it falls, it will be measured to the highest point after falling.

ENGINEERING DESIGN CYCLE

ASK: How does the test process affect your design? What makes this activity challenging?

IMAGINE: What ideas do you have for reaching your goal? What is your best idea?

PLAN: Draw a diagram of your design below. What are the roles of everyone in your group? What is your plan for finishing in the time allotted?

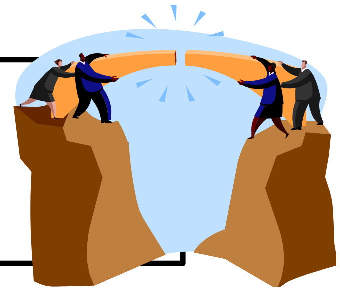
CREATE: Carry out your plan and test your design. Did everything go exactly as planned? Was your design successful? Why or why not?

How tall was your tower?

IMPROVE: What was good about your design? What would you do differently if you did this activity again?

Pasta Bridges

Objective: To design and build a bridge made from uncooked pasta that hold the most weight for the least cost.



Materials:
Pasta - various shapes
Hot Glue Gun Sticks

Tools:
Ruler
Hot Glue Guns
Calculator

Activity Details: You have $2000 to buy pasta, and the cost of your design is what you buy, not what you use. You may sell back undamaged pieces for 50% of the original cost. A matchbox car must be able to roll across the bridge.

Test Process: The bridge will be tested while resting on a 12-inch table gap. A toy car will be rolled from one end to the other. Then, marbles will be placed in a cup on the middle of the bridge until it cracks or tips so that the cup falls. The second to last marble is the number that the bridge can hold successfully. The final score of a bridge is the fraction of marbles held successfully over the total cost.

ENGINEERING DESIGN CYCLE

ASK: How does the test process affect your design? How will you construct a bridge out of pasta that can hold the most weight?

IMAGINE: What ideas do you have for reaching your goal? What is your best idea?

PLAN: Draw a diagram of your design below. What materials will you use? What are the roles of everyone in your group? What is your plan for finishing in the time allotted?

Item	Cost	Quantity	Cost of Quantity
Macaroni	$10		
Ziti	$15		
Spaghetti	$20		
Linguini	$50		
Rigatoni	$50		
Lasagna (2 max)	$80		
		Total Cost	

CREATE: Carry out your plan and test your design. Was it successful? Why or why not?

What was the final score of your bridge? ____________ # marbles / total cost

IMPROVE: What was good about your design? What can you make better?

Self-Folding Shapes

Objective: Use different shapes and designs to explore the folding properties of shrink film under heat.

Materials:
- Paper
- Shrink Film

Tools:
- Scissors
- Markers

Activity Details: You will first cut out the pre-designed shapes on paper and fold them into 3D shapes. Then you will cut out the pre-designed shrink film shapes and observe how they fold under the heat lamp. Finally, you will draw your own shapes based on what you observed.

ENGINEERING DESIGN CYCLE

ASK: What are the properties of the shrink film? (What do the shapes do when they are exposed to the heat lamp?)

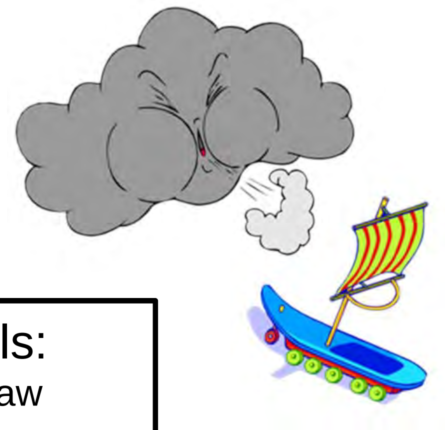
IMAGINE: What ideas would you like to create with the shrink film? What is your best idea?

PLAN: Draw your design below.

CREATE: Carry out your plan and test your design. Did the final 3D figure look like you expected it to? Why or why not?

IMPROVE: What was good about your design? What can you make better? What other shapes would you like to try?

Objective: To design a vehicle powered by wind that can travel the fastest in a straight line on a track.



Materials:

- 2 straws
- 4 Lifesavers
- 1 piece of paper
- 2 paper clips
- Masking Tape: 1 arm's length
- 1 item from Resource Bin

Tools:
1 straw
Scissors

Activity Details: You will have 5 minutes to imagine and plan, 20 minutes to create your design, 10 minutes to test, 10 minutes to improve and rebuild, and 15 more minutes to re-test and clean up.

Test Process: Only one team will test at a time. Your teacher will time with a stopwatch while one team member powers the vehicle with their breath by blowing through a straw behind the vehicle. The course is a straight track that is 1 foot wide by nine feet long. The fastest vehicle is the winner, and interference is not allowed.

ENGINEERING DESIGN CYCLE

ASK: How does the test process affect your design? How will you design a vehicle that is powered only by wind?

IMAGINE: What ideas do you have for reaching your goal? What is your best idea?

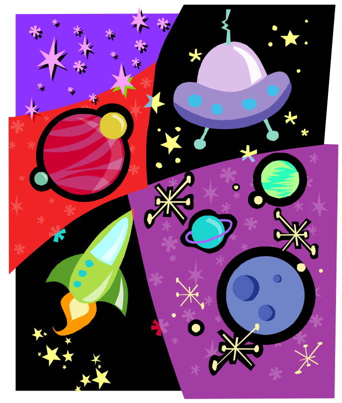
PLAN: Draw a diagram of your design below. What materials will you use? What are the roles of everyone in your group? What is your plan for finishing in the time allotted?

CREATE: Carry out your plan and test your design. Was it successful? Why or why not?

How much time did it take for your vehicle to travel the course?

IMPROVE: What was good about your design? What can you make better?

Objective: To create a rocket with a parachute from a 2-liter bottle and launch via an air launcher.



Materials:

- 2-liter bottle
- Cardstock
- Cardboard
- Duct Tape
- Masking Tape
- Clay
- String
- Dental Floss
- Plastic Bags
- Grocery Bags
- Trash Bags

Tools:

- Hole Punchers
- Goggles
- Air Launcher

Activity Details: You will have 10 minutes to imagine and plan and 30 minutes to build your rockets.

Test Process: The rockets will be launched outside using the Aquapod Air Launcher at 50 psi and timed using a stopwatch. The flight time is the amount of time from launch until the rocket lands on the ground. All campers must stand 15 feet away from the launcher, and the person launching the rocket must wear safety goggles.

ENGINEERING DESIGN CYCLE

ASK: How does the test process affect your design? How will you make your rocket have the longest flight?

IMAGINE: What ideas do you have for reaching your goal? What is your best idea?

PLAN: Draw a diagram of your design below. What materials will you use? What are the roles of everyone in your group? What is your plan for finishing in the time allotted?

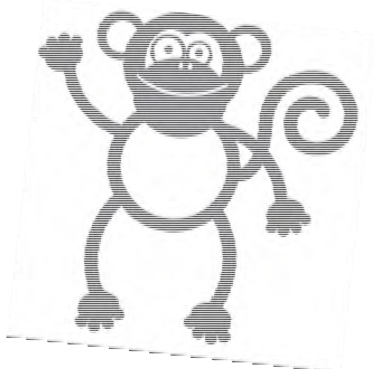
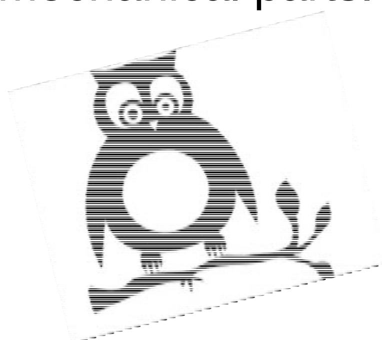
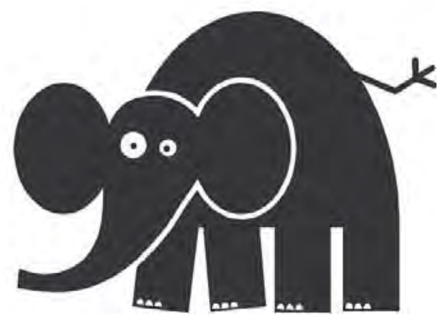
CREATE: Carry out your plan and test your design. Was it successful? Why or why not?

What was your flight time? ___________________

IMPROVE: What was good about your design? What can you make better?

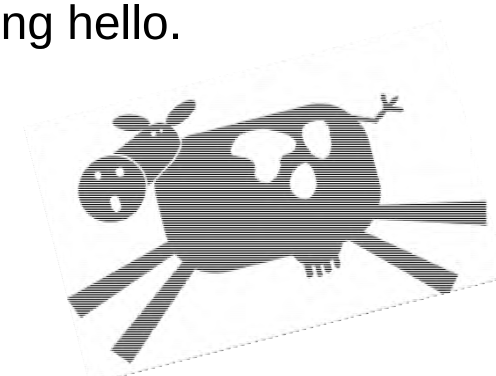
Think about the world around us.

Both humans and animals alike have moving body parts. From arms to legs, toes, eyes, and necks, these critters have lots of moving mechanical parts.

The bodies of humans and animals are both examples of Engineering. Inside of us we have lots of moving mechanisms which allow us to do different task such as running, climbing and even waving hello.



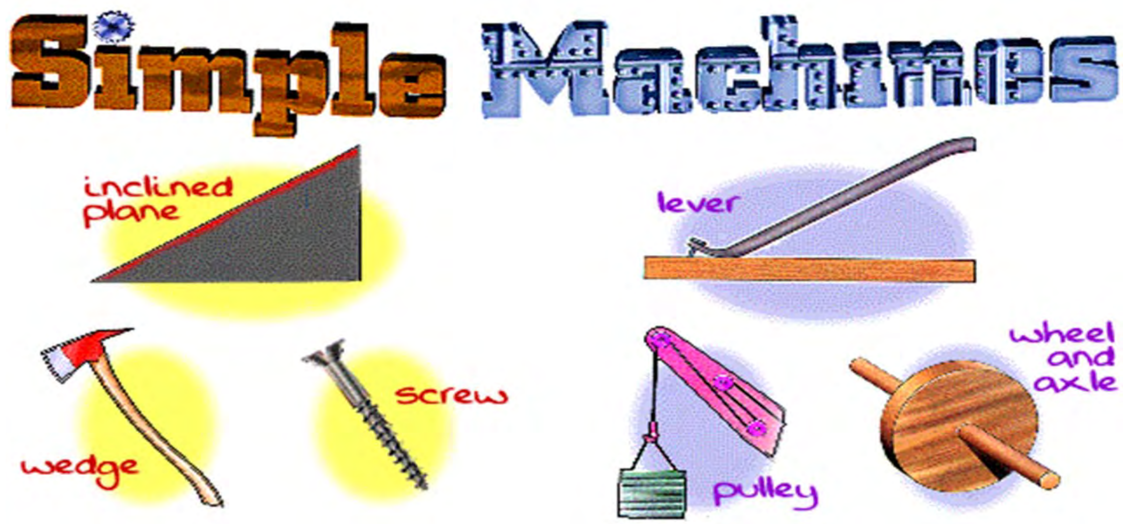


A mechanism is a system of parts that can create motion. Examples of mechanisms we have include our arms. Our arms act like a lever where bone and muscle combine to help produce movement. Try bending your arm back and forth.

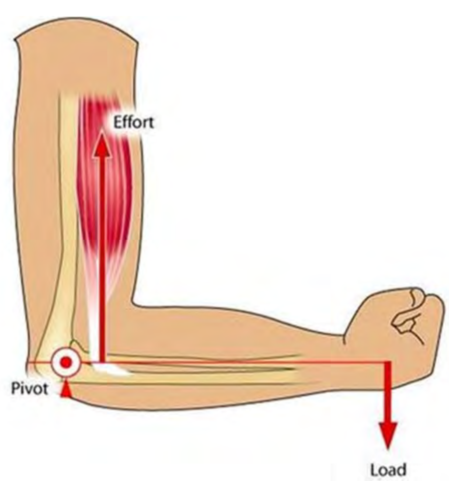
Bodies in Motion

All bodies are made up of mechanisms. A mechanism is a system of parts that can create motion.

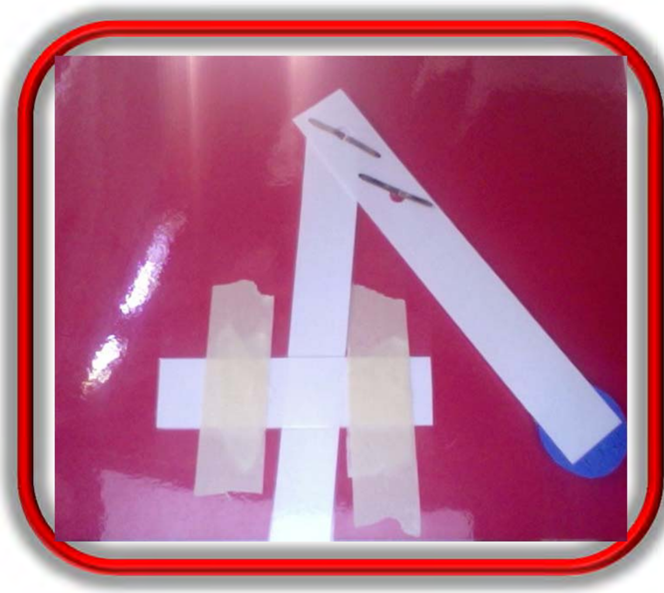
Simple machines are examples of mechanisms. The six types of simple machines include lever, pulley, inclined plane, wedge, screw, and wheel and axle.

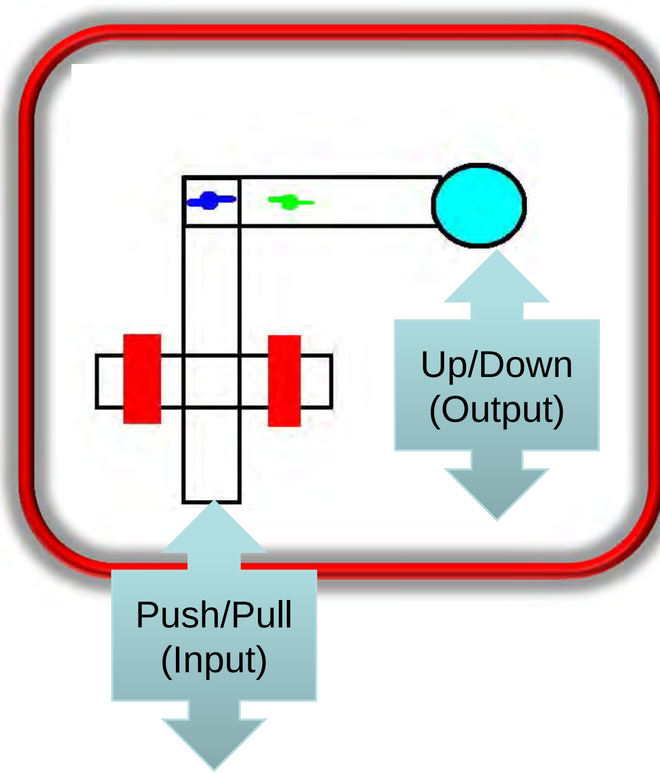


Examples of mechanisms we have include our arms. Our arms act like levers where bone and muscle combine to help produce movement. Try bending your arm back and forth.



Floating around the room are examples of critter mechanisms. Below is an example of a drawn critter diagram based off of the handout.





Points labeled input and output explain the motion done by the critter's mechanism. An input is something you do to get an output. For example if you pull or push the tab (input) the critter's hands move down or up (output)

Note that some pins are **free floating** which is in blue (not connected to the critter's body) while others are **fixed** which is in green (connected all the way through the critter's body).

In the given space below draw some of the mechanisms you see. Don't forget to label the **floating** pins in blue and the **fixed** pins in green.

Mechanism 1

Mechanism 2

Mechanism 3

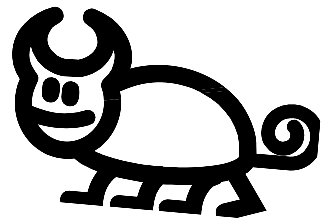
Mechanism 4

Create A Critter

Objective: To design and create a critter with 2 different moving parts

Materials:
Brass Fasteners
Colored File Folders
Paper Strips

Tools:
Scissors
Hole Punchers
Pencils
Markers



Activity Details: Using what you have learned about moving mechanisms, draw and create a critter that has two moving mechanisms.

ENGINEERING DESIGN CYCLE

ASK: Think about the moving mechanisms you just explored. How will you include these parts in your critter?

IMAGINE: Brainstorm. What type of critter will you make? What parts of the critter will move?

Create A Critter

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PLAN: Draw a diagram of your design below. Be sure to include the moving mechanisms in your drawing.

CREATE: Collect your supplies and create your critter. What kind of movements does it have?

How do the movements help to create your critter's personality?

IMPROVE: Do your moving mechanisms work the way you wanted them to? _______ How can you improve your critter?

Egg Crash Gravity Cars

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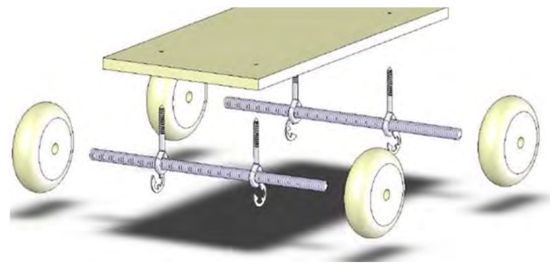
Objective: To create a car that can protect an egg while the car rolls down a steep ramp and crashes into a wall.

Materials:
- Plastic Base
- 4 Eye Screws
- 2 Wooden Axles
- 4 K'nex Wheels/ Tires
- Hot Glue Sticks
- 4 Cotton Balls
- 4 Rubber Bands
- 1 Balloon
- Tape
- Resource Bin Materials

Tools:
- Hot Glue Guns
- Scissors



Activity Details: Following the figure on the right, the eye screws will be screwed into the plastic base and the axle rods will be placed through the eyes. The K'nex wheels will be hot glued to the ends of the rods. Building the protective system is all up to you!

Test Process: The cars will roll down a ramp that is 4 feet long and 2 feet high at its highest point. They will crash into a wall at the bottom of the ramp. If the egg has no visible damage, the challenge has been successfully completed.

ENGINEERING DESIGN CYCLE

ASK: How does the test process affect your design? How will you protect your egg?

IMAGINE: What ideas do you have for reaching your goal? What is your best idea?

PLAN: Draw a diagram of your design below. What materials will you use? What are the roles of everyone in your group? What is your plan for finishing in the time allotted?

CREATE: Carry out your plan and test your design. Was it successful? Why or why not?

IMPROVE: What was good about your design? What can you make better?

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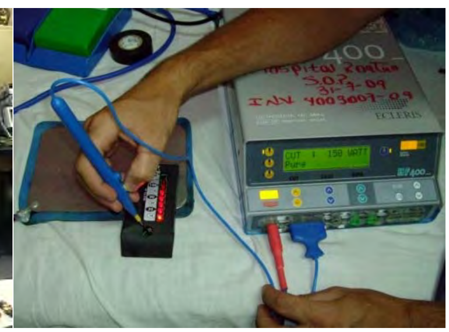
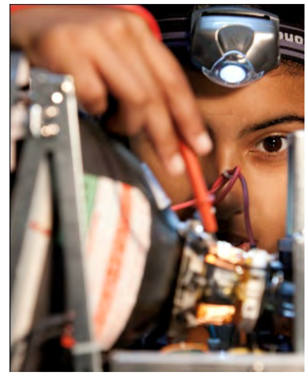


Bioengineer Workshop Activity Booklet

Body Movements	Heartbeat	Electromagnetism	Electrocardiogram	Breathing

Welcome, future Bioengineers!

Biomedical Engineering



Have you ever heard of a Bioengineer or "Biomedical Engineer"? Bioengineers have a vast knowledge of different engineering disciples (mechanical, electrical, chemical, material etc.) and apply this to the human body and the healthcare field in general. As a Bioengineer, you could be building an artificial heart, researching how our brains work, fixing medical equipment or even creating new skin in a lab! It is one of the broadest fields of engineering, and often crosses over with medicine.

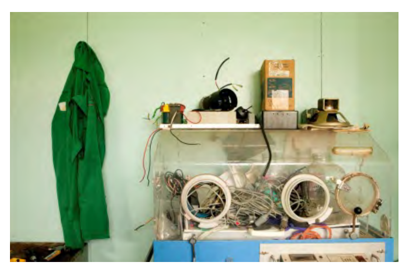
Bioengineers are mentally flexible, have a broad understanding of many different subjects and are good at working in teams. The work that they do often times helps save lives, so they need to be thorough and focused when at work. They work in developing countries in America and Europe, as well as developing countries in Africa, Central America and Asia.

Most often, Bioengineers need to go to University and study for 3-10 years before they are certified. Today, you will get the opportunity to become and EWH Certified Bioengineer via this workshop!

Workshop Outline

This workshop was created to give elementary school students (K-6) an introduction into the work of a Bioengineer, put into the context of a global health setting. It is an interactive, hands-on exploration of anatomy, engineering and real challenges which Bioengineers face in resource-poor settings. Themes such as medical equipment donations or medical device equivalents are explored while students are led through five fun activities. Upon completion of the activities and questions, each student will receive a *Certificate of Achievement* showing that they have successfully "graduated" the EWH Bioengineer Workshop.

EWH is a non-profit NGO (Non-Governmental Organization) that specializes in creating and running Equipment Technician Training (BMET) Programs in Ghana, Cambodia, Rwanda and Central America as well as working closely with engineering students and staff at over 40 Universities around the world. EWH supports, encourages and oversees appropriate technology development for resource-poor settings as well as runs a hands-on equipment repair institute in Central America and Tanzania for college students and professionals.



For more information about EWH, please visit our website:
www.ewh.org

For any questions or feedback regarding the EWH STEM Health Program, please contact Alex Dahinten (EWH STEM Coordinator):
STEMHealth@ewh.org

We hope you enjoy the final product as much as we enjoyed creating it!

Thank You

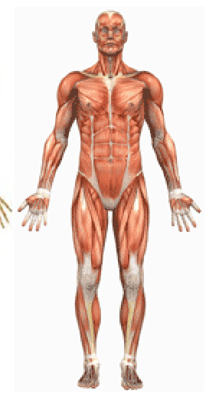
Many thanks to NCSU's The Engineering Place, without whose support this curriculum could not have been completed. Specifically, EWH would like to thank Laura Bottomley, Susan D'Amico and Lindsey Genut for their time and expertise lent to this project. Finally, thank you to Marciano Palha de Souza, EWH Volunteer, for his help with developing this curriculum.

Body Movements (Joints, Muscles and Bones)

Intro

Materials	
• 1x Body poster • 2x Door hinge • 1x Stackable children's toy • 1x Ball and socket joint • 2x Craft sticks (tongue depressors)	• 2x Large (size 32) rubber bands • 2x Small (size 12) rubber bands • Ruler • Scissors • Marker pen

One of the many fields which a Bioengineer will work on is called **biomechanics**. Biomechanics is the study of how living beings, like humans, move through a complex (but very structured) grouping of bones, muscles and joints. This allows us to bend, walk, run and stretch relatively easily! Can you think of any other movements our muscles, bones and joints help us perform?

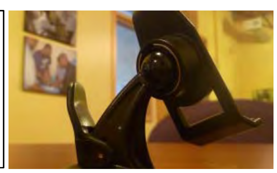


Did you know? Every muscle in our body is controlled by signals coming from our brain; muscles are connected to bone and when they contract/ relax they cause the bone to move with it! The human body contains 206 bones and 640 different muscles!

Activity 1: Body Hinges

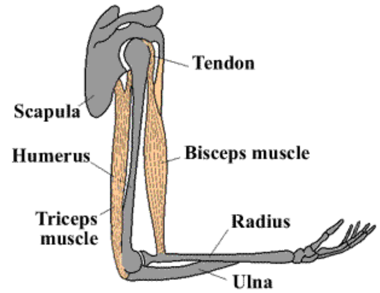
Play with and discover the three different kinds of connector joints featured below. Discuss in a group the different kinds of movements the joints can make. Do they go backwards, forwards or round in a circular motion? Is motion restricted in some cases?

Which body parts do you think each connector resembles <u>the most</u>? Place the connector object onto the poster of a soccer player and connect it with the correct body part below.

Cell Phone Holder (Car) *Ball and Socket Joint* Circular movement		
Door Hinge *Hinge Joint* Bending back and forth in one plane		
Stackable Toy *Pivot Joint* Rotation around a central column.		
Door Hinge *Hinge Joint* Bending back and forth in one plane		

Activity 2: Model Arm

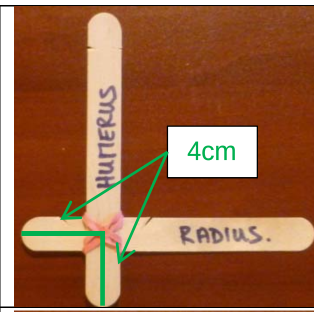
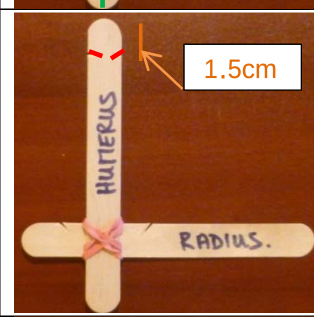
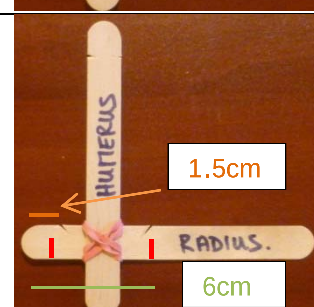
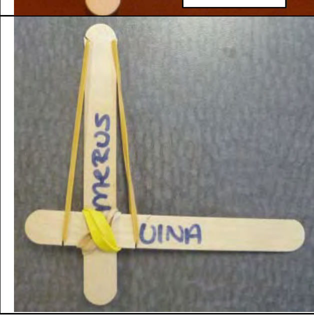
In this activity, you will create a model of your arm and learn about how your muscles and bones work together to move it. Some useful vocabulary:



Muscle contraction: when the muscle is put under tension and (in effect) becomes shorter and fatter. This effect generates the "pull" motion we use to move and lift objects.

Muscle relaxion: opposite of contraction; the muscle is not under tension and therefore is larger in size.

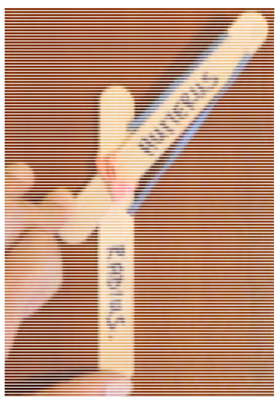
Try contracting your biceps. Can you feel it getting shorter?

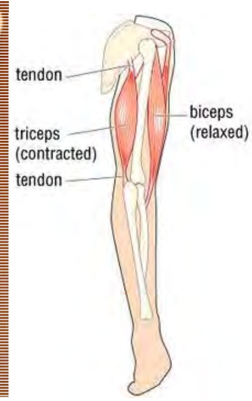
1	Form an "L" shape with two tongue depressor "bones". Use a ruler to make sure the bones overlap at about 4cm from the ends.	
2	Wrap two small rubber bands round the overlap of the sticks, making an "X" shape with the bands.	
3	Now, write "Humerus" on the upright tongue depressor, and on the horizontal one write "Radius" on one side and "Ulna" on the other.	
4	Cut two slightly angled notches in the top of the humerus (red), one 1.5cm below the top on either side. **Be careful not to cut all the way through, a small cut will do!** *You may want to have a grown-up help you with this.*	
5	Cut notches on the bottom side of the radius/ ulna (red); one 1.5cm from the left and one 6cm from the left side.	
6	Very carefully fix the ends of the long rubber bands in the notches as pictured. The rubber band on the *inside* of the "L shape" is called the **biceps muscle**; the one on the *outside* is called the **triceps muscle**. *You may need to make the notches slightly bigger if the rubber band doesn't fit.*	

The biceps and the triceps are known as **antagonistic muscles.** Try using your model and your own arm to figure out what antagonistic muscles are. Observe the change of shape of the rubber bands (muscles) as you move the tongue depressors (bones).

Biceps contraction:

Triceps contraction:





Fill in the blanks with following words: *contracts, bones, shorter, relaxes* and *muscles.*

1. When my biceps contracts, the muscle becomes ____________________.

2. When my biceps contracts, my triceps ____________________.

3. When one antagonistic muscle relaxes, the other ____________________.

4. When my ____________________ contract, it causes my ____________________to move too.

Heartbeat (The Heart)

Intro

Materials	
• 1x Rubber tubing (¼in inner diameter) • 1x Small funnel (¼in outer diameter) • 1x Balloon	• Scissors • 1x Stopwatch • 1x Medical Stethoscope

The heart is one of the most important organs we hav; it is a muscle which contracts to push blood to the rest of the body. Our entire body (from head to toe) relies on blood for nutrients and oxygen. When we exercise, our bodies need more nutrients so our heartbeat increases. A heartbeat is knows as a **pulse** and changes dramatically between exercise and rest. A resting pulse is between 60-90 **beats per minute (BPM)**, whereas an exercising heart can beat up to 200 -220 BPM.

Did you know? A heart beats more than 2,500,000,000 times in an average lifetime which corresponds to about 191,625,000 gallons of blood! But every beat, the heart pumps only 0.02 gallons!

There are many ways Bioengineers can measure the heartbeat (or pulse); two popular ways are:
1. Manually: approximate your heartbeat by holding your fingers on main arteries which transport blood. The largest ones are on your wrist (**radial artery**) and your neck (**carotid artery**).
2. Stethoscope: invented in 1816; this device allows doctors to hear the patient's pulse directly from the heart.

You'll be learning about (and using) both methods to measure your pulse!

Figure 1: Radial artery, Carotid artery, Stethoscope

Activity 1: Manual

1	Place your index and middle finger on either your radial or carotid artery and locate your pulse (like in the picture above).
2	When the leader tells you to, begin counting your pulse. After 10 seconds you will be asked to stop.
3	Record this number below and multiply it by 6 – this is your **resting BPM**.
4	Now stand up and get your heart beating fast! Do jumping jacks for 15-20 seconds. **Be careful not to hurt yourself or anyone around you.**
5	Sit down and measure your pulse again for 10 seconds, multiply this number by 6 and record in the table – this is your **active BPM**.

Resting Pulse: ____________ X 6 = ____________

Resting Beats (10s) *Resting Beats (1 min)*

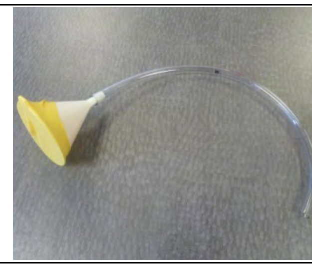
Active Pulse: ____________ X 6 = ____________

Active Beats (10s) *Active Beats (1 min)*

Compare your results with other members of your group. Did everyone have the same BPMs? Probably not! This is because our hearts are all different and it is influenced by factors like the ones listed below. Put an "↑" next to the ones which you think cause you to have a higher heartbeat, and draw a "↓" next to the ones that cause you to have a lower one.

Factor	↑ or ↓
Exercising	
Stress	
Sleeping	
Being overweight	
Being healthy	

Activity 2: Stethoscope

1	Cut out a piece of the balloon that is large enough to fit over the large opening of the funnel (cut about ¼ balloon from opening).	
2	Completely cover the large opening of the funnel and make sure it is tight!	
3	Fit one end of the rubber tubing over the narrow end of the funnel. It should fit very snugly.	

Now, take the large, rubber covered end of the funnel, and place it on your left part of your chest and slightly centered.

Place the narrow end of the tube into your ear, **being careful not to stick it in too deep**! Can you hear a thumping noise? That's your heartbeat! Try using the medical stethoscope to listen to your heart as well.

Tip: If you have a sweatshirt on try removing it first so you can hear your heart better.

What is that thumping noise you hear? It is actually valves opening and closing inside of your heart. **Valves** are kind of like doorways, allowing blood to flow from one "room" into another. When they close, they make a very faint noise which is what you observed.

The heart is made of four "rooms" (or **chambers**), each of which stores the blood for a short time until it passes it to the next chamber, or to the rest of the body. Valves are important because they prevent a back-flow of blood once it has been pumped.

Can you find all four valves in the heart diagram below? Write down their names:

1. ______________________________________

2. ______________________________________

3. ______________________________________

4. ______________________________________

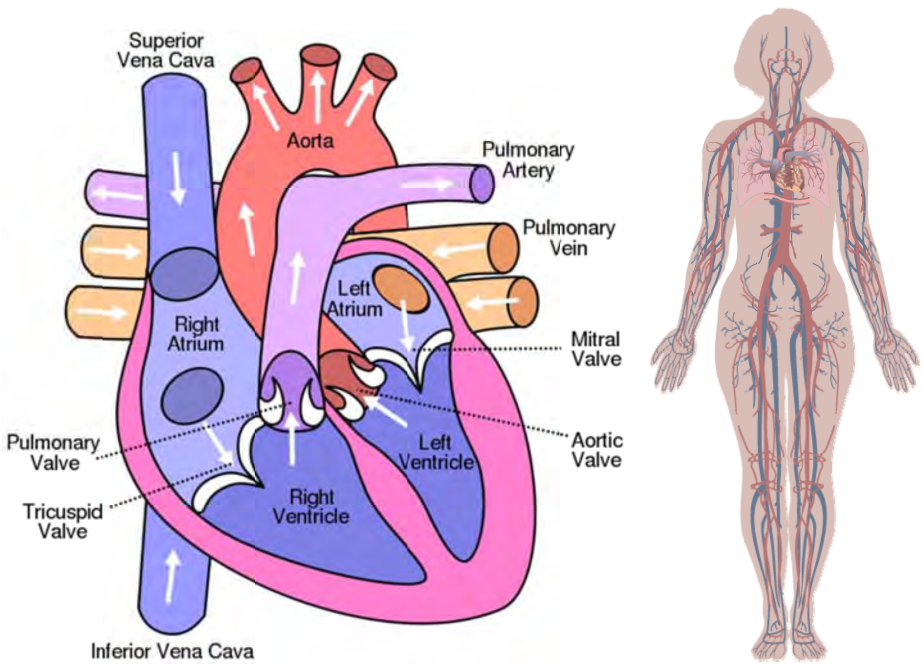


Figure 2: The Human Heart and Blood Flow throughout Body

Electromagnetism (Cup Speakers)

Intro

Materials	
• 1x round magnet (½ to ¾ inch diameter) • 15ft, 20-24 gauge coil wire (enamel-coated) • 1x cup • 1x D-cell battery	• Sandpaper • Electrical tape • Radio w/ detachable speakers (min. 20W output)

Magnets are incredibly important and are used all around us! Things like car doors, computers, vacuum cleaners, TVs and even radio speakers work because of magnets.

As a Bioengineer, you will come across some machines which also use magnets, such as an MRI (**Medical Resonance Imaging**) machine. MRI's allow doctors to see inside your body, without having to perform surgery - they use a special kind of magnet called an **electromagnet**.

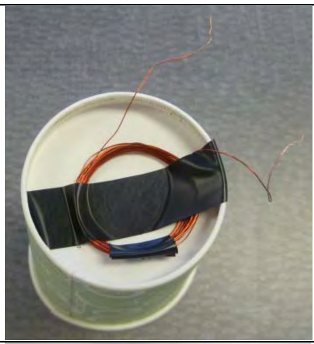
Did you know? When electricity flows in a wire, it creates a very small magnetic field? By turning the wire into a coil, this effect can be enlarged to produce an electromagnet! Pretty cool, huh?

In this activity, you will be making a radio speaker using an electromagnet.

Activity

<table>
<tr><td>1</td><td>Wind 15 feet of wire around the D-cell battery. Leave about two inches of wire hanging off each end.</td><td rowspan="2"></td></tr>
<tr><td>2</td><td>Rub sandpaper on each free wire end to remove about 1 inch of enamel insulation. Show your activity leader when you think you removed enough.</td></tr>
<tr><td>3</td><td colspan="2">While keeping the wire in the shape of a coil, carefully remove it from the object and tape the coil so it does not unravel.</td></tr>
<tr><td>4</td><td colspan="2">Hold the ends of the wire to opposite ends of the battery. Move the coil close to the magnet and observe its motion. Hook the battery up differently and see what happens to the magnets.

(When the coil is connected to the battery in one way, one side of the coil is the north pole and the other side is the south pole of the electromagnet. The north pole of the electromagnet will be attracted to the south pole of the permanent magnet. When the battery is turned around, the poles of the electromagnet are reversed.)</td></tr>
<tr><td>5</td><td>Attach the permanent magnet to the bottom (inside) of the cup with tape.</td><td></td></tr>
</table>

6	Attach the coil to the bottom (outside) of the cup with tape. There are many different creative ways to do this that will work!	
7	With the help of an activity leader, connect the ends of the speaker wire to the speaker output of the radio. Choose the plugs for one speaker (the left, for example) and insert one end of the wire from the cup speaker into one hole, and the other end of the wire into the other.	

Turn the radio on and adjust the volume. When more current flows through the wire coil, the electromagnetic force increases. As the radio changes the current very fast, the changing electromagnetic force causes the plastic cap to vibrate. The vibration creates sound waves in the air, which is what you hear as sound!

The speaker wires may get hot. When electric current flows through the wire, some of the electrical energy is converted to heat energy due to the resistance inside the wire.

There are a few ways to make your electromagnet stronger; put an "X" in the two boxes next to the ones which you think will increase the strength of your electromagnet:

1. Increase current (electricity) through wire.
2. Cover the open end of the cup.
3. Add more coils.
4. Cover the coils in plastic.

Below are 4 MRI scans. Do you recognize which body parts have been scanned? Fill in the boxes with the names of the body part.

Electrocardiogram (Medical Device Donations)

Intro

Materials	
• 1x Small bowl or cup • 1 Teaspoon salt • ½ Teaspoon flour • Water • 1x Spoon	• 3x Bottle cap lining or (plastic cutout) • 3x Nickel-plated brass snap, size 3 • Medical tape • 1x Portable ECG machine & leads • Wet wipes

In most western countries (including the USA) we are used to seeing high-tech, modern working medical equipment when we visit the hospital. However, when this equipment is replaced oftentimes the old units are donated to poorer countries where they are needed.

Donating medical equipment is a fantastic thing to do, however it is important to make sure that the donation is necessary, in working condition and contains all little items which comes with it. For example, a donated x-ray machine is useless if it does not include the x-ray photographic paper film! We cannot assume that hospital staff in resource-poor setting can find (or afford) consumables.

Medical Device Consumable: an item or part of the medical device which is either used up quickly, or disposable. Examples include patient pads, wires, syringes, gas tanks etc.

A major challenge in this field is providing **ECG (Electrocardiogram) pads**. ECG's monitor patients' heart rates before, during and after surgery. The pulse is measured via *disposable* electrode pads placed on the patient's skin, and discarded after use to avoid diseases spreading. ECG pads are cheap, and readily available in the USA, however they are much more difficult to find in poorer countries.

Engineering World Health has come up with a cheap, locally available and reusable solution to this challenge!

Figure 3: Donated medical equipment being repaired by EWH students

Activity

1	Firstly, we need to make a **conductive gel** in order for us to get a better pulse reading later on. Add 1 teaspoon of salt, ½ teaspoon flour and a few drops of water and mix together in a bowl until it has a gunky texture. Put it to the side.	
2	Push a pin through the middle of the bottle cap liner and poke the tip of a pen though the hole to enlarge it.	
3	Place the sewing snap through the hole. You may need to trim away some of the plastic “overhang” around the nub; get a grown-up to help you with this. *These will be our electrodes! They are cheap, reusable and can be disinfected before use on a new patient.*	
4	We are now ready to measure the heartbeat! Find a partner (“the patient”) to perform this test on. *You are <u>not</u> applying any electricity to your friend, but rather measuring electricity running through their skin…it’s 100% safe!*	
5	Ask your patient to hold out one of their wrists and use the pipette (or spoon) to place one drop of the conductive gel on the inside of each wrist.	
6	Lay the flat end of a pad over the conductive gel and tape it down with medical tape, making sure that you leave the nub exposed.	
7	Repeat the above two instructions on the left leg, close to the ankle. *Note: it may be more comfortable for your patient to put their leg up on a chair.*	
8	Once all three electrodes are in place, place the correct wire lead on the correct location i.e. **RA → right arm, LA → left arm and LL→ left leg**. *Tip: The wire lead should click into the electrode snap.*	
9	To take the reading, turn the machine “On” and click “Start” while the Measurement row is highlighted. *Tip: Make sure your patient has their arms lying comfortably on their knees and do not move their arms or legs - this gives a noisy (bad) signal.*	
10	Remove the pads and offer the patient a wet wipe.	

So how does this pad work? The bottle cap lining provides mechanical support for the **electrode**, which is the nickel snap button. The metal electrode can detect the very small electrical impulses from your heartbeat, and display this on a monitor!

Draw the pattern you observe in the box to the right and compare it to the one on the previous page.

Breathing (The Lungs)

Intro

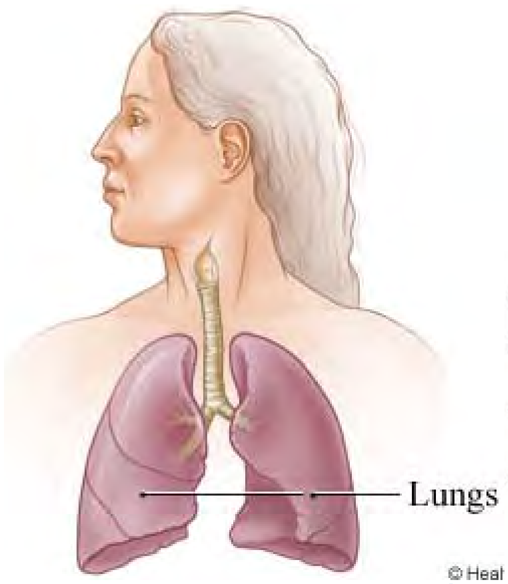
Materials	
• 1x balloon	• 2x ruler

Bioengineers often come up with creative experiments to monitor the condition of the human body. These tests are more difficult, however, when measuring inside the body. Try taking a ruler and measuring how long your foot is. Easy enough, right? Now try measuring how large you lungs are. In this activity you are going to do exactly that - measure the capacity of your lungs!

Teamwork is also very important for a Bioengineer, since they often work with other doctors, engineers, nurses etc. Your team will work together to help measure each other's lung capacities.

Your lungs are essential to breathing. But why is breathing important? Our bodies need oxygen from the atmosphere to survive and our lungs help "suck in" this important molecule from our surroundings.

Did you know? Not only do our lungs help bring oxygen into our bodies, they also help get rid of another gas called **carbon dioxide** every time we breathe out! Carbon dioxide is created as a by-product of reactions in our bodies, and is useless to us.



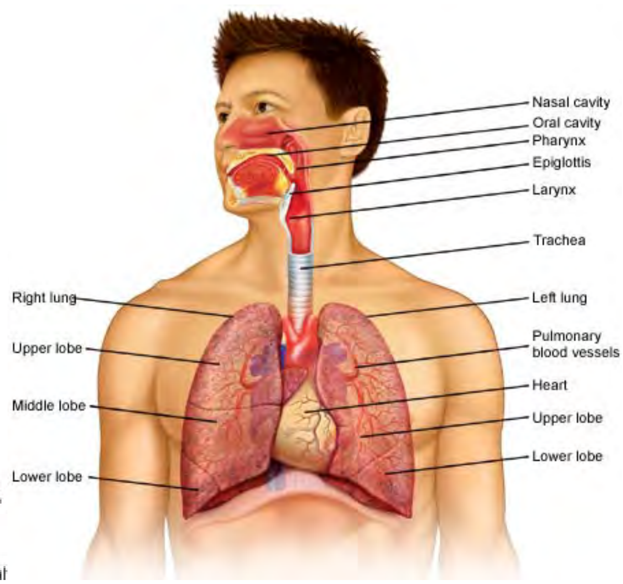


Figure 4: Human Lungs

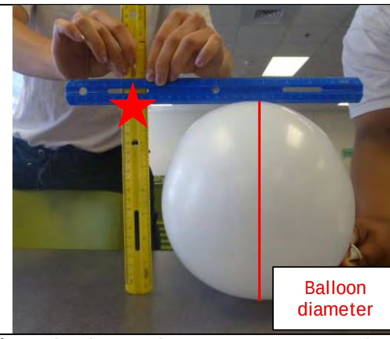
The most important measurements for a Bioengineer are:

1. **Vital capacity (VC):** the largest amount of air that can be exhaled after a deep breath.
2. **Expiratory reserve (ER):** the amount of air that remains in the lungs after exhaling normally (the extra air that can be breathed out).
3. **Tidal volume (TV)**: the amount of air taken in (or exhaled) during normal breathing.

Vital Capacity = Expiratory Reserve + Tidal Volume

You will be measuring all three, lucky you!

Activity

1	Find a partner and decide who will go first. Have them stretch their balloon several times.
2	Take as deep a breath as possible and **exhale all the air you can into the balloon**. *This is your vital capacity (VC) diameter measurement.* 
3	Pinch the balloon closed to prevent air from escaping.
4	Ask your partner to help hold the two rulers while you measure the diameter of the balloon where the rulers overlap, red star.
5	Record the diameter of the balloon in centimeters in the table below (VC). Make sure you round your result up or down.
6	Use the graph on the last page to find your corresponding lung capacity and fill in the table.
7	Now, inhale normally then exhale normally. **Then exhale the REST of the air still in your lungs into the balloon.** *This is your expiratory reserve (ER) diameter measurement.*
8	Measure and record the diameter of the balloon (in cm) in the table like you did previously.
9	Use the graph on the last page to find the lung volume that goes with the diameter and record this too.
10	Take in a normal breath. Exhale into the balloon only as much air as you would normally exhale. **DO NOT force your breathing.** *This is your tidal volume (TV) diameter measurement.*
11	Measure and record the diameter of the balloon (in cm) in the table like you did previously.
12	Use the graph on the last page to find the lung volume that goes with the diameter.

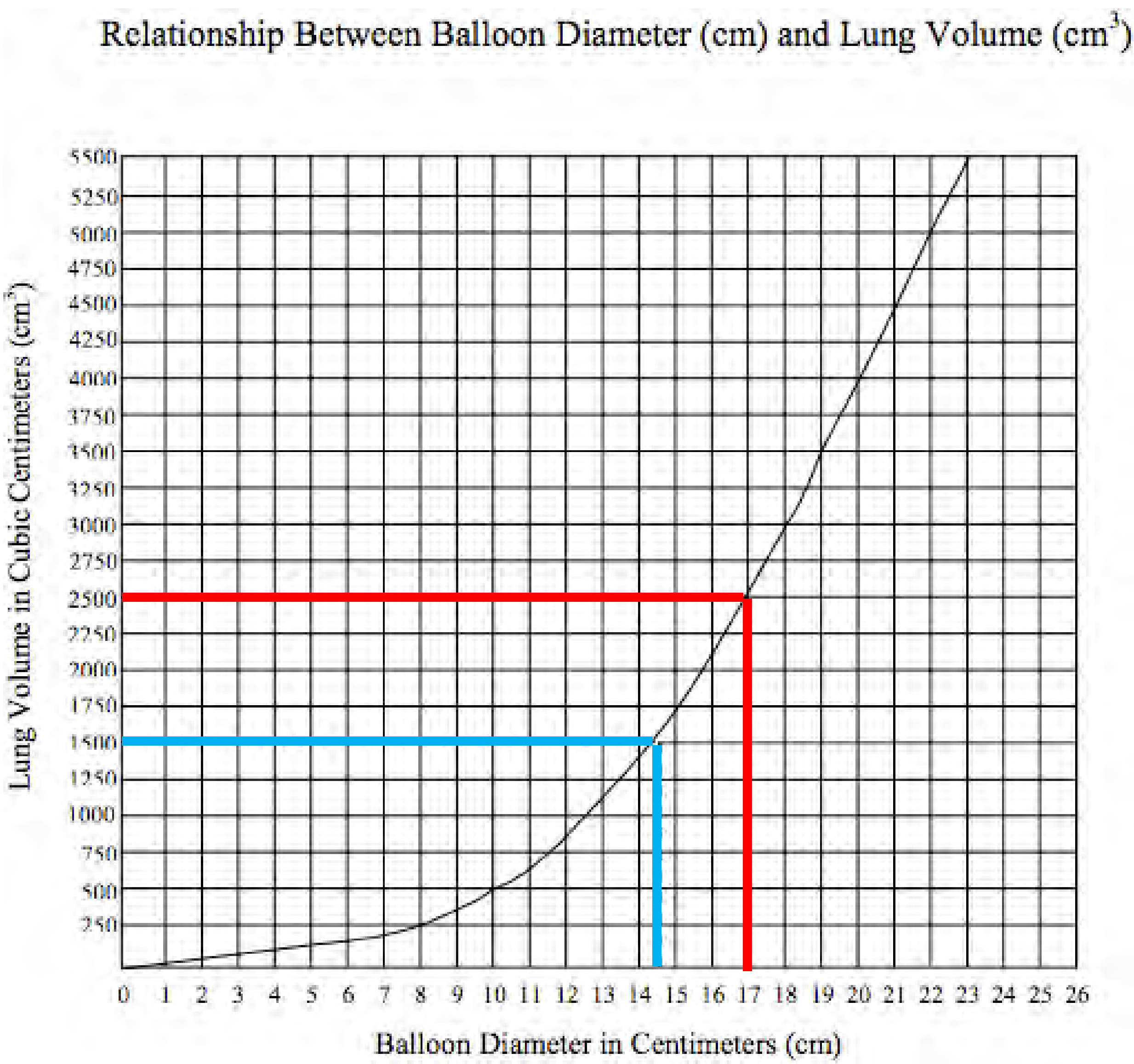
	Diameter measurement (cm)	**Lung Volume (from graph, cm^3)**
Vital capacity (VC)		
Expiratory Reserve (ER)		
Tidal Volume (TV)		

Compare your results with your partners. Do you notice any differences? What is different?

Circle the option you think completes the sentence the best, and discuss why you chose it:

1. An athlete who plays sports every day has *larger/ smaller* lungs than someone sitting in front of the TV every day.
2. A short person has *larger/ smaller* lungs than a tall person.
3. A smoker has *stronger/ weaker* lungs than a non-smoker.
4. My lungs are about the size of two *golf balls/ melons/ soccer balls*.

How to use the below graph:
Find your corresponding diameter measurement on the X- axis and follow the line plot to get a lung volume approximation. *For example, if your balloon diameter is 17cm, your corresponding lung volume is 2500cm^3(red line). If your balloon diameter is 14.5cm, your corresponding lung volume is 1500cm^3 (blue line).*



Draw an Engineer

Objective: In the space below, draw what you imagine an engineer looks like.

Goals: Think about how much you have learned this week and how much engineers impact our daily lives.

Draw an Engineer

What does your engineer look like?

How has your drawing changed since the beginning of this week?

What other things do engineers do that you could not fit into your drawing?