Getting to the Core

Grade 7 Unit of Study

STUDENT RESOURCES

Bionic Hand

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HAND - Lesson 1 Name__________________________ Period_____

Quick Write on Injury

I am person ______ (A, B, C, or D). Think about a time that you or someone you know suffered an injury to your hand or foot. How did the injury occur? How long did it take for the injury to heal? What were some of the limitations you or the person had while recuperating from the injury? Write about it in the space below:

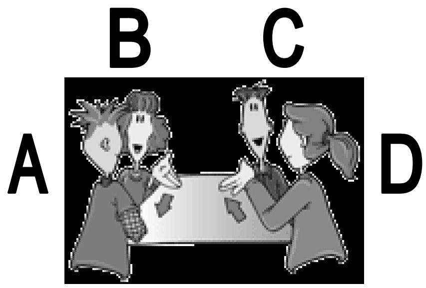
I am going to interview person _____(A, B, C, or D). Interview your partner. Ask them to tell you about a time that they or someone they know suffered an injury to their foot or hand. Write notes about what they say. Be sure to include the limitations they had while recuperating from the injury. Bullet points are fine. Get as many details as possible. You will be using these notes to report out to the other two members of your base group.

THREE STEP INTERVIEW

(Kagen)

Three Step Interview:

How it Works



Step One: A interviews B

while

C interviews D

Step Two: B interviews A

while

D interviews C

Step Three: 1. A reports to the whole group about B

2. B reports to the whole group about A

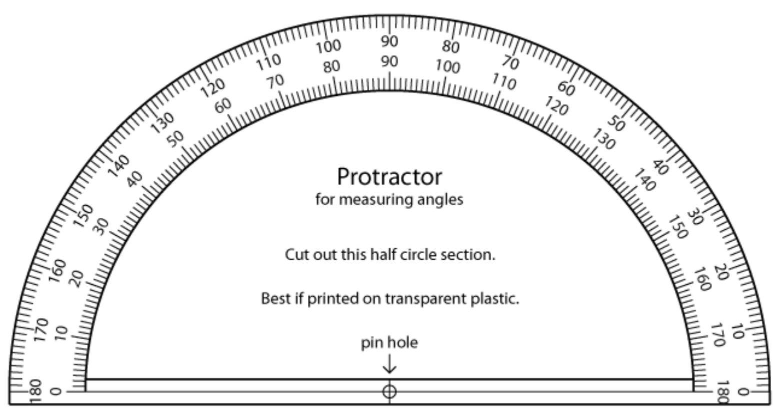
3. C reports to the whole group about D

4. D reports to the whole group about C

Using a goniometer to measure Range of Motion for a knee joint

http://www.idass.com/acatalog/goniometer.jpg

You can use your own protractor or cut out the one below to measure the angles on the next pages:

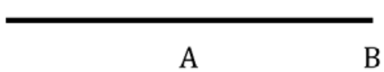


This page left blank intentionally to allow the protractor to be cut out

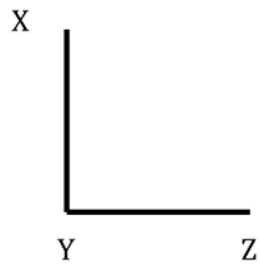
Lesson 1 Name ____ Period _______

Angle Measure

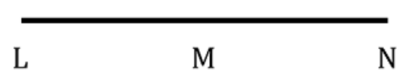
Use a protractor to measure each of the angles given and write your answer in the space provided.



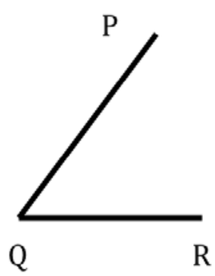
∠ ABA ______



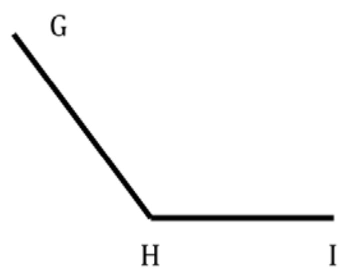
∠ XYZ ______



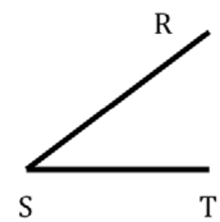
∠ LMN ______



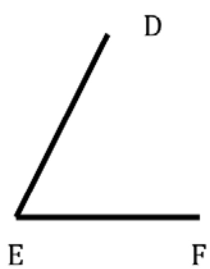
∠ PQR ______



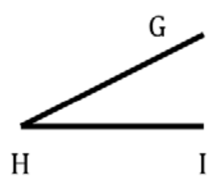
∠ GHI ______



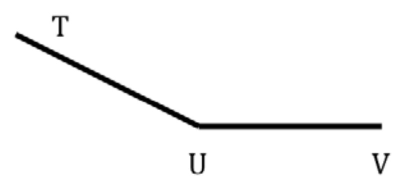
∠ RST ______



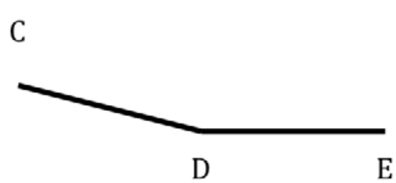
∠ DEF______



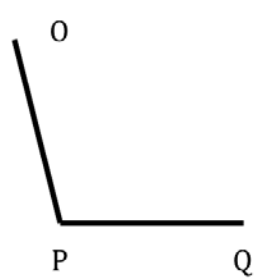
∠ GHI ______



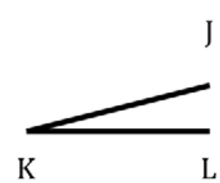
∠ TUV ______



∠ CDE ______



∠ OPQ ______



∠ JKL ______

HAND Lesson 1 Name ______________________________ Period ________

Drawing Angles

Directions

- Use a protractor to help you draw each of the angles given below
- Use the points given as the vertex while drawing 1-inch legs for each angle

▪ 90^{o}	▪ 45^{o}	▪ 30^{o}
▪ 60^{o}	▪ 180^{o}	▪ 120^{o}
▪ 10^{o}	▪ 110^{o}	▪ 0^{o}

Wrist Range of Motion (ROM) Instructions

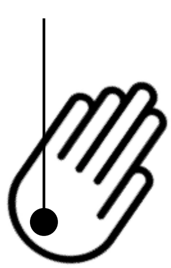
Step 1

Place the bottom of the palm of your right hand onto the circle • on the next page of this ROM Data Sheet with the middle of your hand along the ‘centerline’.

centerline

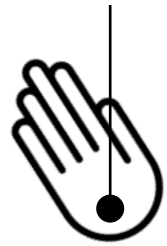
Step 2

Rotate your hand as far as you can to the right without picking your hand off of the paper then trace your hand again. Your wrist and arm MUST stay flat on the paper.



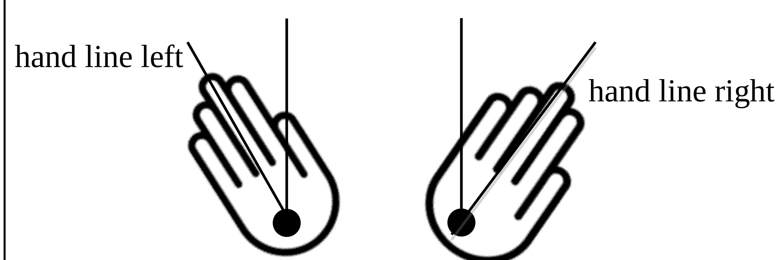
Step 3

Rotate your hand as far as you can to the left without picking your hand off of the paper then trace your hand again. Your wrist and arm must stay flat on the paper.



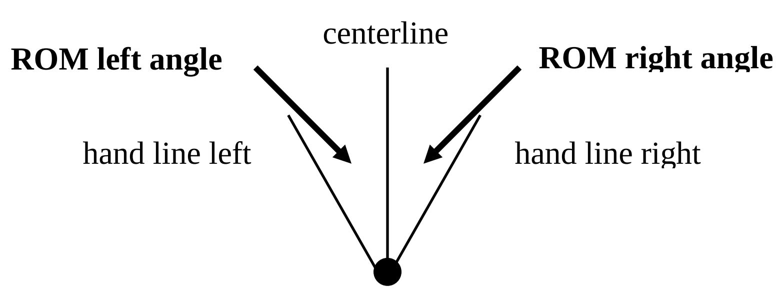
Step 4

Use a ruler to draw a straight line onto the paper starting at the ‘centerline’ circle and passing through the middle of each of the hand tracings you made in Steps 2 and 3.



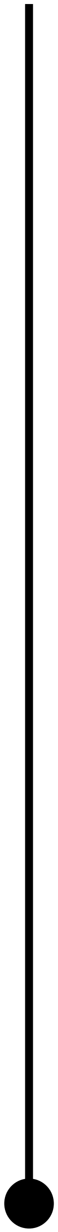
Step 5

Use a protractor to measure the angle between the ‘centerline’and each of the rotated ‘hand lines’ for both the left and right hand.



Step 6

Enter your rotation data from Steps 1 through Steps 5 into the Range of Motion (ROM) Data Chart then repeat the experiment for your left hand.



Wrist Range of Motion (ROM) Data Chart

_______________ Hand

ROM right _________

ROM left _________

2004–20 N05 ASA SCI Files™

National Aeronautics and Space Administration

I Want To Hold Your Hand

Purpose

To construct a robotic-like hand and to demonstrate how data are collected when using robotic technology.

Background

A robot is a machine that collects information from its surroundings. It uses that information to follow instructions and to complete a task. Today's Robots have multiple sensors and are able to make their own decisions based on given information. Robots come in all shapes and sizes. The jobs they do are also varied. Some robots are used in factories. Others are experimental robots that use artificial intelligence. Artificial intelligence allows robots to behave more like human beings and to act independently in a changing environment. Today, robots are used in hospitals, space and ocean exploration, and other dangerous areas.

Materials Per Person

Narrow rubber bands

Drinking straws

Cardboard

Tape

Scissors

Nylon cord, fishing line, or lanyard

Centimeter ruler

Pen

Procedure

1. To make the palm of the robotic hand, cut a piece of cardboard 10 cm x 10 cm.
2. To make the fingers, cut three pieces of cardboard 2 cm x 9 cm.
3. To make one of the fingers jointed, cut one of the cardboard pieces into three equal pieces. See diagram 1.

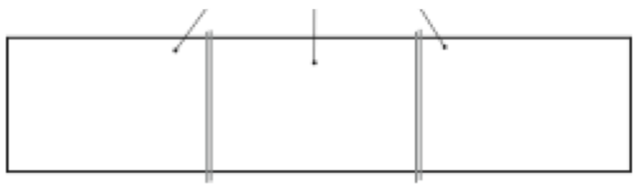


Diagram 1

4. Place the three equal finger pieces back together and use tape to reconnect them. Label one side of the taped finger "inside." See diagram 2.

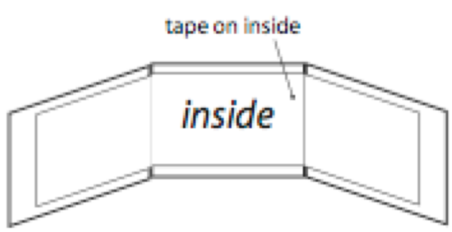


Diagram 2

5. Cut a rubber band 5 cm long.
6. Turn the segmented finger over so the "inside" is face down.

7. Put the rubber band across the middle of the first joint. See diagram 3.

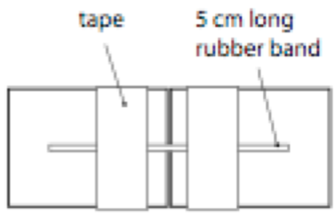


Diagram 3

8. Tape the rubber band on both sides of the joint, making sure to leave the ends of the rubber band untaped.
9. Fold the ends of the rubber band so that they rest on top of the tape and tape them firmly in place. See diagram 4. Taping prevents the rubber bands from slipping.

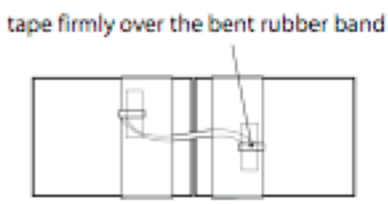


Diagram 4

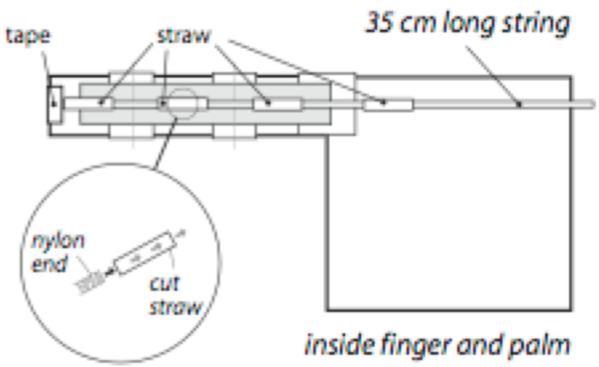
10. Repeat steps 5 through 9 for the second joint.
11. Tape the finger onto the palm with “inside” facing up.
12. Turn the hand over.
13. Cut a rubber band 5 cm long.
14. Put the rubber band across the last joint (touching the palm).

15. Repeat steps 8–9 for the last joint, connecting the finger to the palm. See diagram 5.

connecting fingers to palm

Diagram 5

16. Cut a piece of nylon cord 35 cm long.
17. Tape one end of the nylon cord over the end of the finger. See diagram 6.

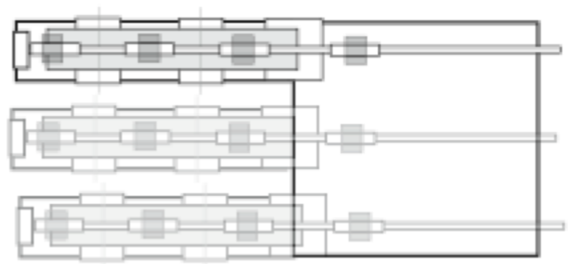


inside finger and palm

Diagram 6

18. Cut four pieces of straw 2 cm each.
19. Thread the pieces of straw onto the nylon cord.
20. Tape a piece of straw in the middle of each finger section.

21. Tape the last straw to the palm. See diagram 7.



inside finger and palm finished

Diagram 7

22. Repeat steps 3–21 for the last two fingers.

23. Operate the hand by pulling the nylon cord.

24. You should be able to pick up an empty soda can or other lightweight objects.

Tips:

- May need to cut the tape pieces to make them thinner.
- Make sure the rubber bands are taped firmly. If there is any loose area, the hand will not work properly.

Conclusion

1. What items can you pick up with your robotic hand? You need to be able to at least pick up a crumpled piece of paper. Can you complete this task? If not, what is wrong with your robotic hand that prevents you from picking up the paper?

2. What would happen if you added more fingers? Think about this for the Engineering Process at then end where you will have opportunity to redesign your project in the last week.

3. What would happen if you added a thumb? Think about what happened when you taped your thumb to the palm of your hand. Again, think about ways you might want to modify your hand.

4. Why is it difficult to pick up certain items with your robotic hand? Are they to big, too heavy, too long?

Part One: Finger Assembly

Directions-Use the procedure section from the **I Want to Hold Your Hand** handout to arrange steps A-D in order. When you have figured out the correct order, and confirmed with your teacher, write the sentences in their correct order in the Flow Map below. Notice the first and final boxes have been completed for you. Self check the order of your flow map procedure when you watch the video. Use pencil to make revisions easier.

NOTE: These are NOT in the correct order. You need to determine the correct order.

A. Use a piece of tape to reconnect them
B. Cut 1 piece of cardboard into three equal lengths
C. Label the side of the finger with tape “inside”
D. Place the three equal finger pieces together

Prepare Materials

Create three 2cm x 9cm cardboard pieces
Gather Scissors, tape, a centimeter ruler, and a pen.

→ [ ] → [ ] → [ ] → [ ] →

Repeat steps 1-4 to create 2 more fingers

Part Two: Finger Assembly Continued

Directions-Use the procedure section from the **I Want to Hold Your Hand** handout to arrange steps A-E in order. When you have figured out the correct order, write the sentences in their correct order in the Flow Map below. Notice the first and final boxes have been completed for you. Self check the order of your flow map procedure when you watch the video

NOTE: These are NOT in the correct order. You need to determine the correct order.

A. Tape the rubber band on both sides of the joint, leave about ½ centimeter of the ends of the rubber band un-taped
B. Cut a rubber band 5 cm long
C. Put the rubber band across the middle of the first joint.
D. Turn the cardboard finger over so the "inside" is facing down
E. Fold the un-taped ends of the rubber band so that they rest on top of the tape and tape them firmly in place

Prepare Materials

Gather: Rubber bands, the 3 taped cardboard fingers you created in part one, scissors & tape

Repeat steps 2-6 to create 2 more fingers

Part Three: Attaching the Fingers to the Palm

Directions-Use the procedure section from the **I Want to Hold Your Hand** handout to arrange steps A-C in order. When you have figured out the correct order, write the sentences in their correct order in the Flow Map below. Notice the first and final boxes have been completed for you. Self check the order of your flow map procedure when you watch the video

NOTE: These are NOT in the correct order. You need to determine the correct order.

A. Turn your hand back over so the "inside" is once again facing down.

B. Tape another 5 cm piece of rubber band across the last joint onto the palm the same way we did the first two finger joints.

C. Turn the finger over so the "inside" is facing up and tape the finger to the "palm"

Prepare Materials

Create: One 10cmx10cm cardboard palm

Gather: Rubber bands, the 3 taped cardboard fingers that you built in parts one and two. centimeter ruler & tape.

You will repeat these steps for each of the other remaining fingers.

Part Four: Attaching the String to the Fingers

Directions-Use the procedure section from the **I Want to Hold Your Hand** handout to arrange steps A-F in order. When you have figured out the correct order, write the sentences in their correct order in the Flow Map below. Notice the first and final boxes have been completed for you. Self check the order of your flow map procedure when you watch the video

NOTE: These are NOT in the correct order. You need to determine the correct order.

A. Turn the hand over so the rubber bands are facing down
B. Cut four pieces of straw 2 cm each and thread each piece of straw through the string taped onto the finger
C. When taping the string, let the knot at the end hang out from the tape
D. Tape a piece of straw onto each finger segment and onto the palm. Be sure not to tape the string to the straws or joints
E. Cut three pieces of nylon string each 35 cm long, and tie a knot on each end of the strings
F. Tape the end of one piece of string onto the end of the first finger on the side with rubber bands

Prepare Materials

Gather: The hand you created in Part Three, a piece of nylon string, & straws.

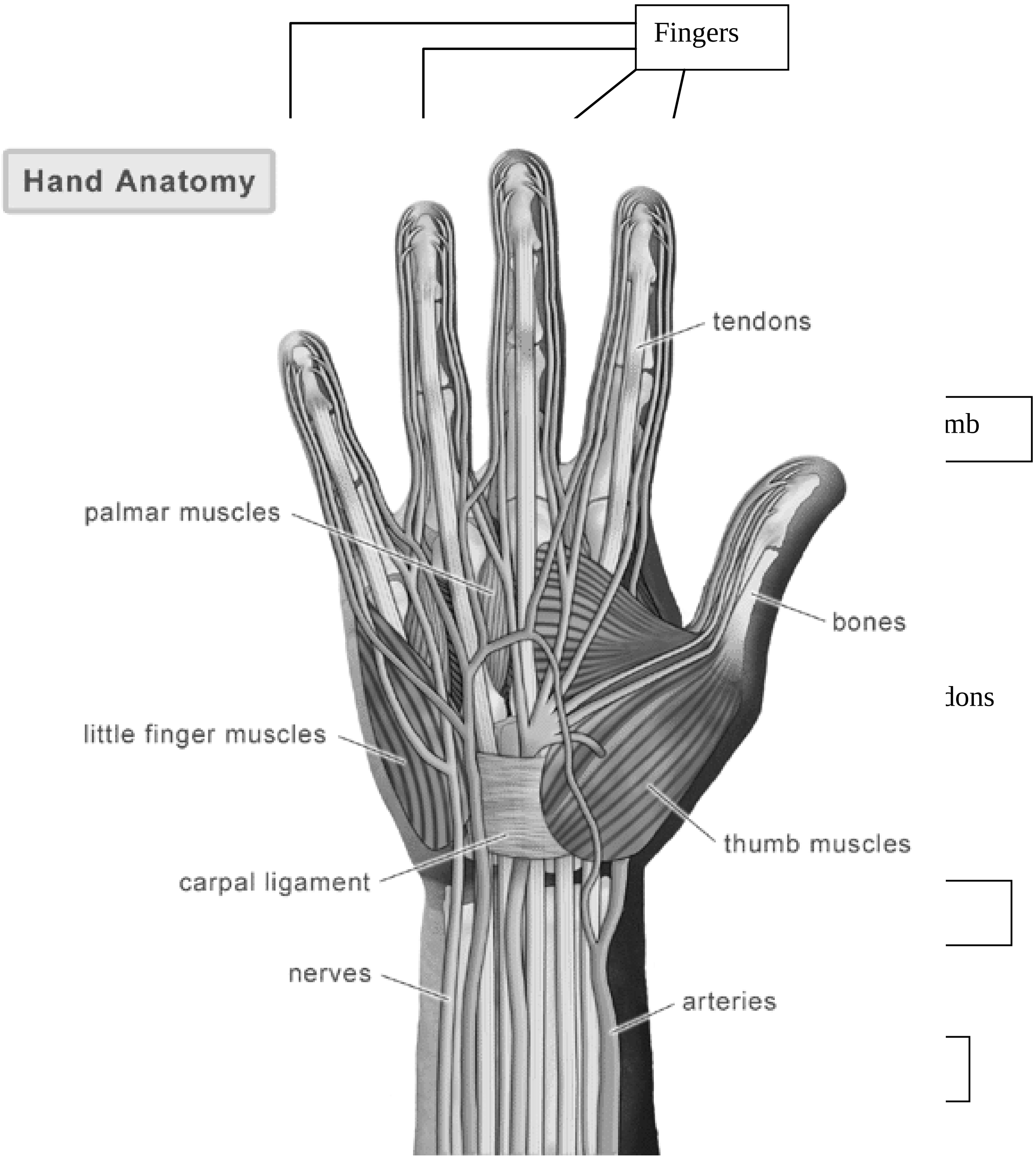
Repeat the steps we used to build this finger to construct the other two fingers.

Name ____________________________ Period __________

Jigsaw Matrix – Parts of the Hand

	Bones & Joints	Ligaments	Muscles	Tendons
Material in the “Bionic Hand Model” (Day 4)				
Describe this part of the hand.				
What is the function of this part of the hand?				
What is one interesting fact about this part of the hand?				

Structure of the Hand

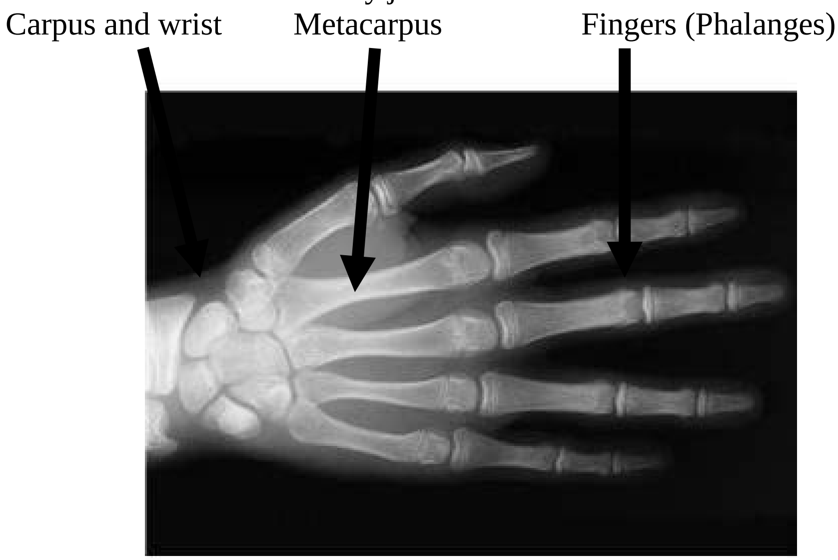


Graphic from:
http://maksimiliana.pl/3/anatomy-of-hand

Bones and Joints

The human hand has a complex structure made up of a total of 27 individual bones: 8 carpal bones, 5 metacarpal bones, and 14 finger bones (also called phalanges [fah-lan´jēz]) are connected by joints and ligaments. About one fourth of all our body's bones are found in our hands.

The hand can be viewed in three sections by joint function:



Wrist
The wrist is made up of two parts working together as one functional unit. It allows us to flex or extend the hand. The hand can also be tilted in the direction of the little finger or the thumb.

Carpus
The carpal bones are held together tightly by ligaments, and are more or less fixed in relation to one another. They form two rows: four carpal bones are in the first row closer to the forearm. Two of these, together with the radius bone form the inferior radioulnar joint, which is very important for the movement of the hand. The ulna is separated from the carpal bones by a cartilage disc. The other joint is located between the two rows of carpal bones.

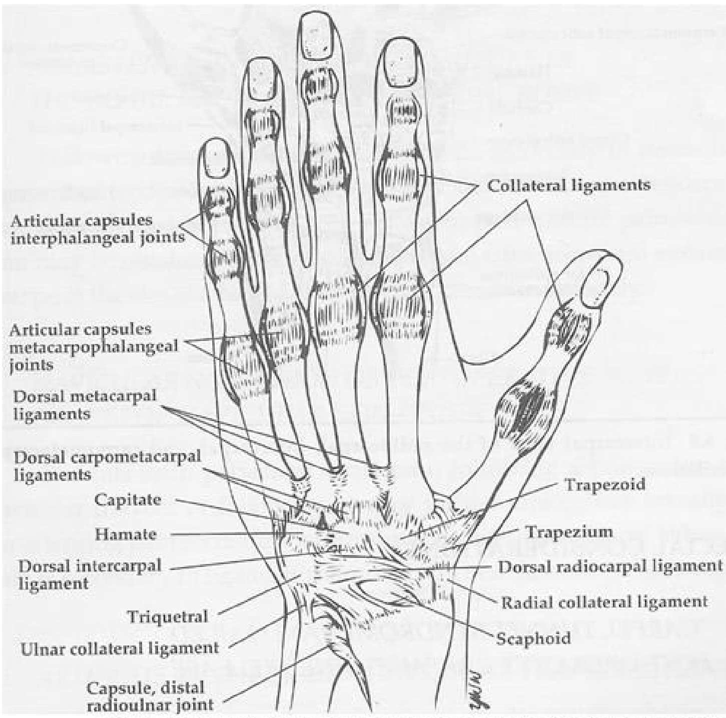
Metacarpus
The metacarpus extends from the second row of the carpal bones. It has five elongated metacarpal bones. You can feel them quite well through the skin on the back of your hand. One of the metacarpal bones together with the thumb's proximal phalanx makes up the carpometacarpal joint of the thumb, giving the thumb better freedom of movement compared with the other fingers.

Fingers
The five fingers make up the freely moveable part of the hand. Each has three individual bones – except for the thumb, which has only two. In each of these four fingers there are three hinge joints, which can only be extended away (extension) or bent inwards (flexion). The thumb, however, can also rotate owing to the carpometacarpal joint so that it can also be positioned opposite the other four fingers.

Adapted from: Informed Health Online [Internet]. Cologne, Germany: Institute for Quality and Efficiency in Health Care (IQWiG); 2006-. How does the hand work? 2010 Aug 31 [Updated 2012 Jan 12]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK83668/

Ligaments in the Fingers and Hand

Hand ligaments are tough but flexible bands of tissues that connect the bones of the human hand with each other and with the bones of the wrist and forearm. While the fibrous bands of tissues called ligaments can serve to connect bones to cartilage or other tissues, they most often connect bone to bone and serve to keep joints intact.



Dorsal view of the radiocarpal, intercarpal, and carpometacarpal articulations

http://www.prolo.ca/images/hand1.jpg

The hand is given structure and flexibility by hand ligaments, which bind together the various small bones that make up the hand and connect it to the wrist. Two large ligaments bind the bones of the hand and wrist to the radius, a bone of the forearm. The first is on the back of the hand and is called the dorsal radiocarpal ligament, and the second, on the palm side of the hand, is called the palmar radiocarpal ligament.

A sprain is an injury that damages a ligament. Grade 1 and 2 sprains are less severe. The internal structure of the ligament in damaged but the ligament remains intact. Grade 3 sprains are more severe. They include complete tears of the ligament. Grade 3 sprains are sometimes called torn or ruptured ligaments.

Symptoms of a sprain may include:

- Pain immediately after the sprain
- A popping sound
- Local swelling, often within minutes
- Bruising
- Trouble moving the joint

Information from:
http://www.wisegeek.com/what-are-hand-ligaments.htm
http://www.bidmc.org/YourHealth/ConditionsAZ/LigamentSprain.aspx

Muscles in the Hand

The hand and forearm, connected by the wrist, make up a functional unit. There are over 30 muscles in the hand and forearm, working together in a highly complex way.

Long forearm muscles
Movements of the hand are mostly started by muscles in the forearm. Only the thin tendons of these muscles are directly a part of the hand: the extensor tendons used for extending the hand run through the back of the hand to the tips of the fingers, and the flexor tendons run through the palms to the fingers.

Short hand muscles
The short muscles of the hand lie between the individual metacarpal bones. They allow us to spread our fingers (abduction) and then press them back together (adduction). They also help us to flex the metacarpophalangeal joints and extend our fingers.

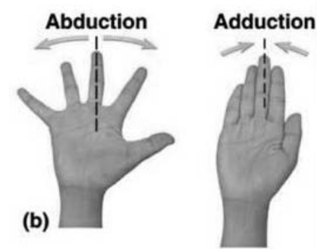


Figure 1 Found at http://anatomystudybuddy.files.wordpress.com/2012/09/abduction-adduction2.jpg?w=470&h=353

The thenar eminence and the hypothenar eminence muscles
Two groups of more powerful muscles in the hand itself make up the thenar eminence (at the base of the thumb) and the hypothenar eminence (controlling the little finger). The thenar eminence helps the thumb to move. This includes the essential movement of opposition, allowing the thumb and the tips of the remaining four fingers to touch. A separate muscle for flexing (adductor) can help move the thumb towards the palm. The muscles of the hypothenar eminence are mainly used for extending and bending the little finger, as well as for tightening the skin that covers the hypothenar eminence.

Lumbricals
The lumbricals of the hand are four thin, worm-shaped muscles that help bend the metacarpophalangeal joints and extend the fingers.

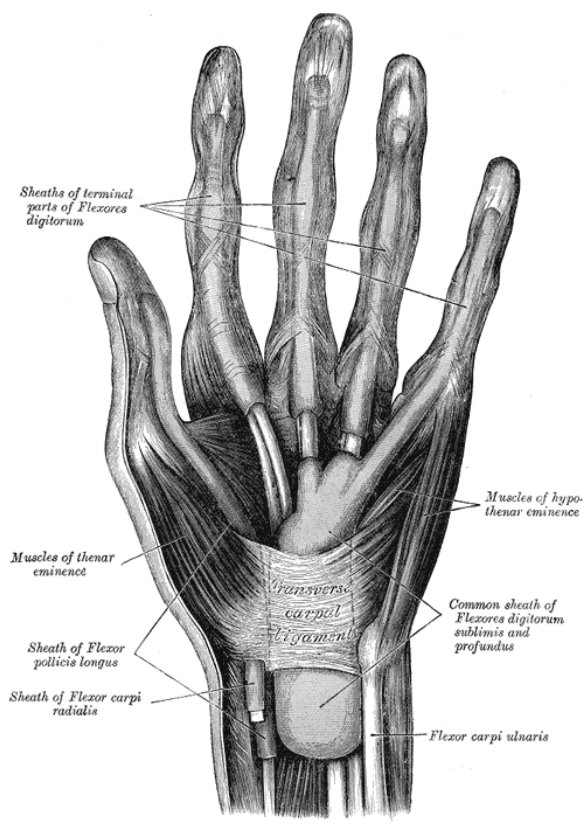


Figure 2"The mucous sheaths of the tendons on the front of the wrist and digits." Henry Gray's Anatomy of the Human Body, 1918.

Adapted from: Informed Health Online [Internet]. Cologne, Germany: Institute for Quality and Efficiency in Health Care (IQWiG); 2006-. How does the hand work? 2010 Aug 31 [Updated 2012 Jan 12]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK83668/

Tendons in the Hand

The hand and forearm, connected by the wrist, make up a functional unit. There are over 30 muscles here, working together in a highly complex way. Each muscle is connected to a bone by a tendon.

Tendons that Control the Hand

One example of how tendons work in the forearm and hand are found in the extensor muscles.

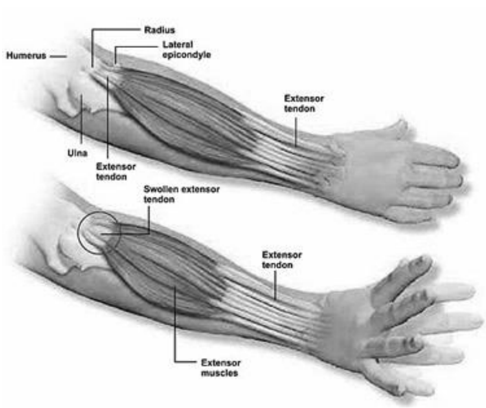


Figure 1
http://www.orthoneuro.com/sites/default/files/tennis-elbow.jpg

Inside the Elbow

The muscles that pull the wrist back are called extensor muscles. These muscles joint together and attach to a single tendon at the elbow. This tendon, called the common extensor tendon, attaches to the lateral epicondyle, the bony bumb on the outer side of the elbow.

Tennis Elbow This condition is a degeneration of the tendons that attach to the lateral epicondyle. This condition is caused by repetitive trauma or aging. Common symptoms include tenderness and pain at the lateral epicondyle, and this pain can be made worse by bending the wrist.

Tendons of the long forearm muscles

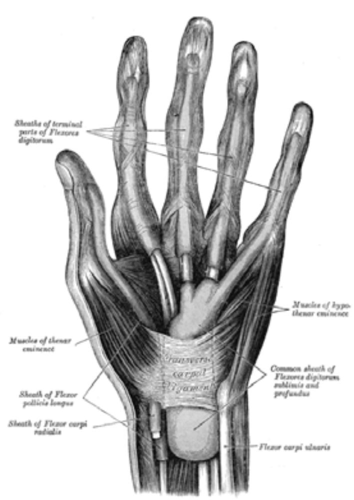


Figure 2"The mucous sheaths of the tendons on the front of the wrist and digits." Henry Gray's Anatomy of the Human Body, 1918.

Movements of the hand are mostly started by muscles in the forearm. Only the thin tendons of these muscles are directly a part of the hand: the extensor tendons used for extending the hand run through the back of the hand to the tips of the fingers, and the flexor tendons run through the palms to the fingers.

The long flexor and extensor tendons of the forearm muscles are partially surrounded by protective layers, called tendon sheaths. They produce a fluid that acts as a joint lubricant to lessen the friction caused by any movement. The tendon sheaths can become inflamed, which may be caused by injuries or by overuse resulting from repetitive uniform motions.

Muscle tendons, nerves and blood vessels run from the forearm to the hand through a passageway, which is level with the wrist on the inside of the hand. This passageway is called the carpal tunnel and is made up of connective tissue and carpal bones. If the tissue around the carpal tunnel swells up as a result of an inflammation or an injury, the nerves may be compressed, causing pain and distortions in sensation.

Informed Health Online [Internet]. Cologne, Germany: Institute for Quality and Efficiency in Health Care (IQWiG); 2006-. How does the hand work? 2010 Aug 31 [Updated 2012 Jan 12]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK83668/

Sample Language to use to Discuss the Structures of the Hand

Student A = Student 1, *Student B = Student 2*, Student C = Student 1, *Student D = Student 2*

Student 1 – What part of the hand connects bone to bone?
Student 2 – The part of the hand that connects bone to bone is . . . .

Student 2 – What is the function of one of the muscles in the hand?
Student 1 – The function of one muscle in the hand is . . . .

Student 1 – What is one effect or limitation when a ligament is torn?
Student 2 – One effect of a torn ligament is . . . .

Student 2 – What is an interesting fact about bones in the hand?
Student 1 – An interesting fact about the bones in the hand is . . . .

Student 1 – What is the function of a tendon in the hand?
Student 2 – The function of a tendon in the hand is . . . .

Student 2 – What parts of the hand are the rigid structures that the tendons and ligaments are connected to?
Student 1 – The parts of the hand that are the rigid structures that tendons and ligaments are connected to are the . . . .

Or create your own sentence starter and response below!
Student 1 - ____

____

Student 2 - ____

____

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Text-dependent (video-dependent) Questions:

While watching the video clip, focus and take notes on the following questions:

1. What is a bionic hand or prosthetic hand?
2. How does it function or work?
3. What is a bionic hand capable of or able to do?
4. What are the limitations of a bionic hand?
5. Who are bionic or prosthetic limbs arms and legs designed for?

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The Bionic Hand Extended Anticipatory Guide

Statements	Agree	Disagree	NOW WHAT DO YOU THINK?			
			Agree	Disagree	EVIDENCE FROM VIDEO to support your argument	EVIDENCE FROM TEXT to support your argument
1. Prosthetic limbs, which are man-made devices used to replace missing body parts, function, or work, exactly like human hands.						
2. Artificial arms and legs can be bought at the pharmacy, like knee braces or ace bandages.						
3. Cosmetic prostheses, which look like natural body parts, do not function, or work. They are just for looks.						
4. It is very expensive and difficult to get a prosthetic limb because they must be custom built for each patient.						
5. Prosthetic limbs help military veterans who were injured in war.						

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Discussion Sentence Frames

To Disagree
(Remember, you disagree with an idea, not the person)

☐Another way to look at it is ________.

☐I understand what you said about ____________, but I think _________.

☐I have a different answer. I wrote down that _______________.

To Agree

☐You made a good point when you said _________.

☐I see what you're saying. I agree because ______________.

☐My idea builds on _______'s idea. I think _________.

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DOD working toward fully functional prosthetic arms

February 1, 2012 By Rob McIlvaine (http://www.army.mil/article/72958/)

NATIONAL HARBOR, Md. (Army News Service, Feb. 1, 2012)

1. A robotic arm, dubbed "Luke," after the Jedi with the mechanical hand, served as the centerpiece for a Jan. 31 discussion here regarding advancements in prosthetics. The robotic arm is a Defense Advanced Research Projects Agency-funded project, in partnership with the Department of Veterans Affairs. The goal of the project is to restore functionality for individuals with upper extremity amputations. The project is still in development.

2. "The original goal for the program, back when we got started in 2005, was to create, within this decade, a fully functional motor and sensory upper limb that responds to direct neural control," said Dr. Stewart Coulter, during the 2012 Military Health System Conference at the Gaylord National Hotel and Convention Center, from Jan. 30 to Feb. 2. Coulter, who serves as the general manager at DEKA Research and Development Corporation in Manchester, N.H., also has the role of product manager for the revolutionizing prosthetic arm system to provide improvements in functionality and usability for wounded warriors and others.

3. The DEKA arm has 10 degrees of movement, and features moving fingers, wrist, elbow and shoulder. All those parts move with electric motors, which are controlled by the user with signals from a foot-based controller.

4. But Coulter said it's easy to confuse the advances being made in prosthetics with science fiction. "A lot of people have seen, for instance, the Terminator movies, and sometimes forget that those aren't actually real," Coulter said.

5. The standard for prosthetic arms up until now has been "two to three degrees of freedom," Coulter said, which is not much different than a prosthetic arm that features a hook. "You see the hand open and close, you're seeing elbow flex, you might see a wrist rotate but not much more than that," Coulter said. "You're seeing low torque, but you're not seeing any feedback to the user."

6. In addition to degrees of freedom in prosthetic movement, Coulter said work being done to combine multiple individual prosthetic movements into single, more fluid movements. He also said there is work being done to find better ways to attach prosthetics to the user's body. "These are the three areas that need to be resolved," he said. "If you can't address making the arm have the capability, if you can't address the control seam part, if you can't address how you attach it to them, it won't do any good to address two of the three."

7. The various grips are also important. "If you want to be able to use a drill, there's a whole different grip," Coulter said. "So now we have a grip that will let you close the index finger independently like that. And you ought to see somebody's face light up who hasn't used a drill in 20 or 30 years."

8. One of the hard parts about this, he said, is finding a way to control a system, given the fact there's now 10 degrees of freedom in the arm. "Current ones are done with myoelectric controls, so they'll use residual muscles and it's very difficult to do that," he said. With the DEKA arm, they are using foot-based controls. "This provides a pretty good level of control, without relying on someone else to do it, relying on a joy stick, or relying on using their other arm to control it," he said.

9. Coulter said his team works very closely with a number of people who have used the arm system, and he says they've let the team know what works, and what needs to be fixed. "We've done clinical studies over the life of the program to improve design and to confirm we got it right," he said. They now have more than 4,000 hours of use time on versions of the arm system. "This has really given us the experience with the people who'll have to use it," he said.

10. Coulter said it's fun to have a group of engineers sit and design something but even more fun to have people use it. "It's been tremendous to work with them and give them the chance to say what activities they want to do," he said. "We've let five people take it home for two weeks, see what they think of it, come back and tell us what's going on."

11. The feedback, he said, has been very positive. "They want to do the things that are important to them, such as, going out to a restaurant and eating with chopsticks or a fork, playing golf, holding a trumpet and playing it, leaning up on a lamppost with an outstretched arm, holding a baseball, or reaching up to the top shelf and picking up a glass of water and holding it level as it's brought down to drink," he said. "To hear them say, 'Yes, I can use this for things I couldn't get done before,' is exactly what we're pushing for here," Coulter said.

DO/SAY Chart to use with DOD Article

Section	DO (function of this section)	SAY (content of this section) *You can paraphrase (restate in your own words) the information from the text.*
1	States the goal of the project.	
2	Provides background information on this project.	
3	Provides details about the DEKA arm.	
4	States a misconception of prosthetics that some people have.	
5	Tells what prosthetic arms were able to do before the DEKA arm.	

Section	DO (function of this section)	SAY (content of this section) *You can paraphrase (restate in your own words) the information from the text.*
6	Describes further improvements of the DEKA arm.	
7	Describes how the grips are important.	
8	Describes how the arm is controlled.	
9	Describes how the arm has been tested by amputees.	
10	Further describes who has tested the arm.	
11	Describes the results of having amputees test the prosthetic arm.	

Engineering Design Challenge – Prosthetic Hand

Scenario

You are working with a team of engineers from a biomedical engineering company that specializes in the design and manufacturing of prosthetic devices. Your team's challenge is to design a prosthetic hand that can perform ONE specific function to help improve the quality of life of the amputee who uses the prosthesis.

Example functions to design for:

- holding a pen or pencil
- clasping
- using sign language
- throwing
- brushing teeth
- picking up and relocating an object
- holding a utensil
- eating spaghetti

Design Constraints

- **Time**: You will be expected to complete this design challenge from start to finish in a matter of days! Therefore, it is important to agree on a design that is functional, yet not overly complex.

Functionality Goals:

Identify and describe the function you have chosen to design for and explain why you chose that particular functionality goal.

Bee creative! ~~~  ~~~~~~

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Engineering Design Process

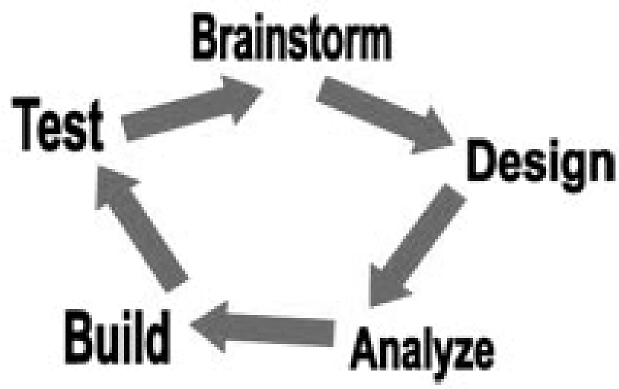
The **engineering design process** is a series of steps that engineering teams use to guide them as they solve problems. Anyone can do it! To determine how to build something (skyscraper, amusement park ride, bicycle, music player), engineers gather information and conduct research to understand the needs of the challenge to be addressed. Then they brainstorm many imaginative possible solutions. They select the most promising idea and embark upon a design that includes drawings and analytical decisions on the materials, construction, manufacturing, and fabrication technologies to use. They create and test many prototypes, making improvements until the product design is good enough to meet their needs.

Engineers design and build all types of structures, systems, and products that are important in our everyday lives. The engineering design process is a series of **steps** that engineering teams use to guide them as they solve problems:

- **Understand the Need:** What is the problem? What do we want to accomplish? What are the project requirements? What are the limitations? Who is the customer? What is our goal? Gather information and conduct research - talking to people from many different backgrounds.

- **Brainstorm Different Designs:** Imagine and brainstorm ideas. Be creative; build upon the wild and crazy ideas of others. Investigate existing technologies and methods to use. Explore, compare and analyze many possible solutions.

- **Select a Design:** Based on the needs identified, select the most promising idea.



- **Plan & Analyze:** Draw a diagram of your idea. How will it work? What environmental and cultural considerations will you evaluate? What materials and tools are needed? What analyses must you do? How will you test it to make sure it works?

- **Build:** Assign team tasks. Build a prototype and test it against your design objectives. Push yourself for creativity, imagination and excellence in design. Does it work? Analyze and talk about what works, what doesn't and what could be improved.

- **Test & Improve:** Discuss how you could improve your product. Make revisions. Draw new designs. Iterate your design to make your product the best it can be.

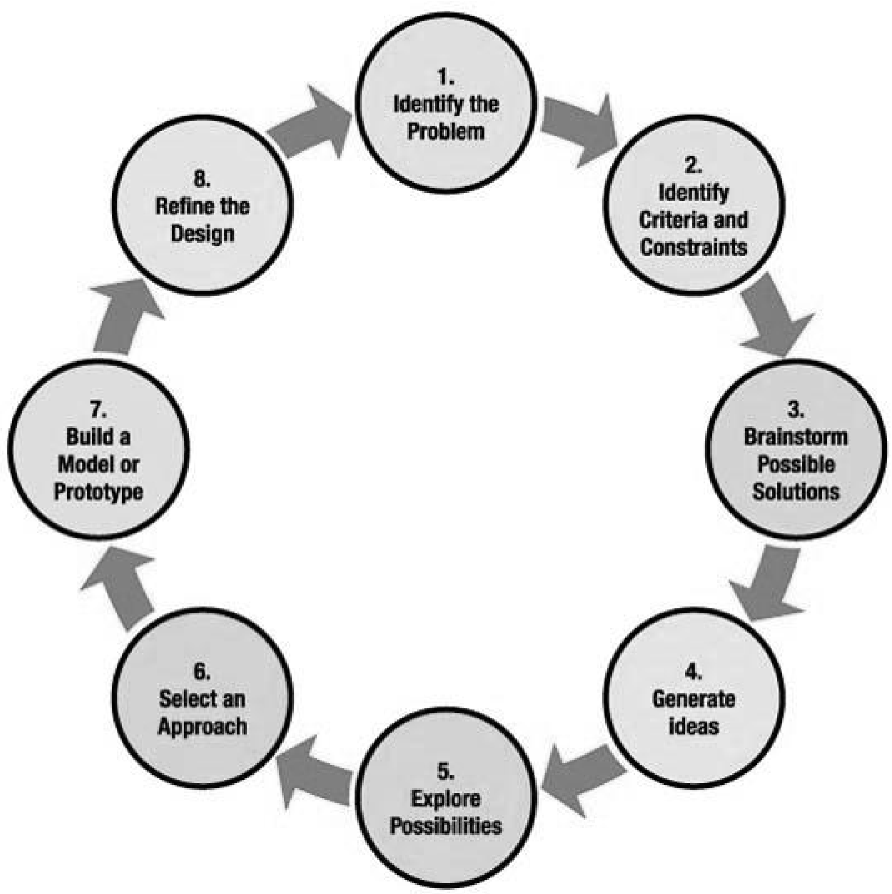
Engineering Design Process *continued*

Engineers use their science and math knowledge to explore all possible options and compare many design ideas. This is called **open-ended design** because when you start to solve a problem, you don't know what the best solution will be to meet the requirements. The process is **cyclical** and may begin at, and return to, any step.

The use of **prototypes,** or early versions of the design (or a model or mock-up) helps move the design process forward by improving your team's understanding of the problem, identifying missing requirements, evaluating design objectives and product features, and getting feedback from others. These **iterations** help the team look at how the prototypes change and improve with each repetition of the design cycle.

Engineers select the **solution** that best utilizes the available **resources** and best meets the project's requirements. They consider many **factors** before they implement a design: Quality, reliability, environmental consideration, safety, functionality, ease of use, aesthetics, ethics, social and cultural impact, maintainability, testability, ease/cost of construction and manufacturability. They also consider **sustainability** - how the development, use and ultimate disposal of the product might impact people and our planet.

For a more detailed Look at the Engineering Process:
http://www.sciencebuddies.org/engineering-design-process



Engineering Design Process: Test & Improve

Practice modifying a device:
After completing a design cycle (designing, building, and testing) your designs should be modified for improvement. How can it work better? As you work on improving your model hand device, think about how to fix specific parts of the device. To help you engineer better working hand models you must consider the tasks that are to be completed with the hand. Is the hand strong enough? Does the hand model have any parts that may cause harm to the person using it and how will the user deal with this? How big will it need to be? Engineers must always be resourceful and use at little materials as possible. Consider the cost. Will it be too expensive to build?

Consider the following:
- How can adding a thumb or more fingers improve your device's functions?
- Is the hand easy to use?
- Are there ways to improve parts of the hand?
- Can using different materials on parts of the device help the hand work better?

Engineering is an **iterative process, a series of improvements**. You built your **1st iteration** of your model hand during the first week of this unit. Each time you build or change parts on the hand it is considered another **"iteration."** Now review these questions again while thinking about your model hand device and try to modify and improve your device for your 2nd and possibly 3rd iterations of the robotic hand prototype.

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Engineering Design Process Cornell Notes

Questions/Main Ideas	Details/Answers
(**After** taking notes write questions that could "test" your understanding of the information in your notes)	(**While you watch and listen** to the power point, write down important facts, details and examples from the presentation)
1.	PULLED QUOTES from BRAINSTORM section
2.	PULLED QUOTES from DESIGN section
3.	PULLED QUOTES from REVIEW (ANALYZE-BUILD-TEST) section

Summary: 1st **Review and Recite** your notes. Then **write a paragraph** summarizing the information in your notes (use T-P-C, t-topic sentence, p-paraphrase, c-conclusion statement)

___

___

___

___

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___

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Vocabulary Notebook

Word	Graphic/Image	Definition /Application **Below: Rewrite the definition in your OWN words.**
Prototype		The original or model on which something is based or formed
Factors		One of the elements contributing to a particular result or situation
Solution		The act of solving a problem, question
Iteration		The act of repeating; a repetition
Open-ended Design		Not restrained by definite limits, restrictions, or structure. Allowing for or adaptable to change

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Defining the Problem

A. Description of Problem, Need or Value
- What are the problems and/or needs that justify the project?
- Describe the target population — who specifically experiences this problem or need?

B. Overview of the Design Team
- What is the mission of the design team?
- What are the team member's qualifications to accomplish this project?

C. Overview of Proposed Project
- What is the basic purpose of the project?
- Who will benefit from it? Describe the geographic area and population to be served.
- How does this project help fulfill the team's mission?
- How is this project unique? For example, is it similar to other projects but designed for a different target population? Does it employ a new approach?

D. Project Requirements and Constraints
- What are the project requirements?
- What constraints have been placed on your team?

E. Project Activities and Timeline
- What exactly must be done in order to achieve the desired outcomes?
- When, and in what order, must these activities be done to achieve the desired outcomes?
- Who will carry out project activities? Who is responsible?

F. Outcomes
- What immediate and long-range results are expected?
- Will these results change people's lives, the educational community and/or the world?

G. Evaluation
- By what criteria will the success or failure of this project be measured?
- What techniques or tools will be used to evaluate?
- Who will do the evaluation? When and how often will they do it?
- How will evaluation results be used? Who will see evaluations?

H. Funding
- What is the anticipated total budget for this project? Give a complete budget breakdown.
- What is the anticipated source(s) of funding?

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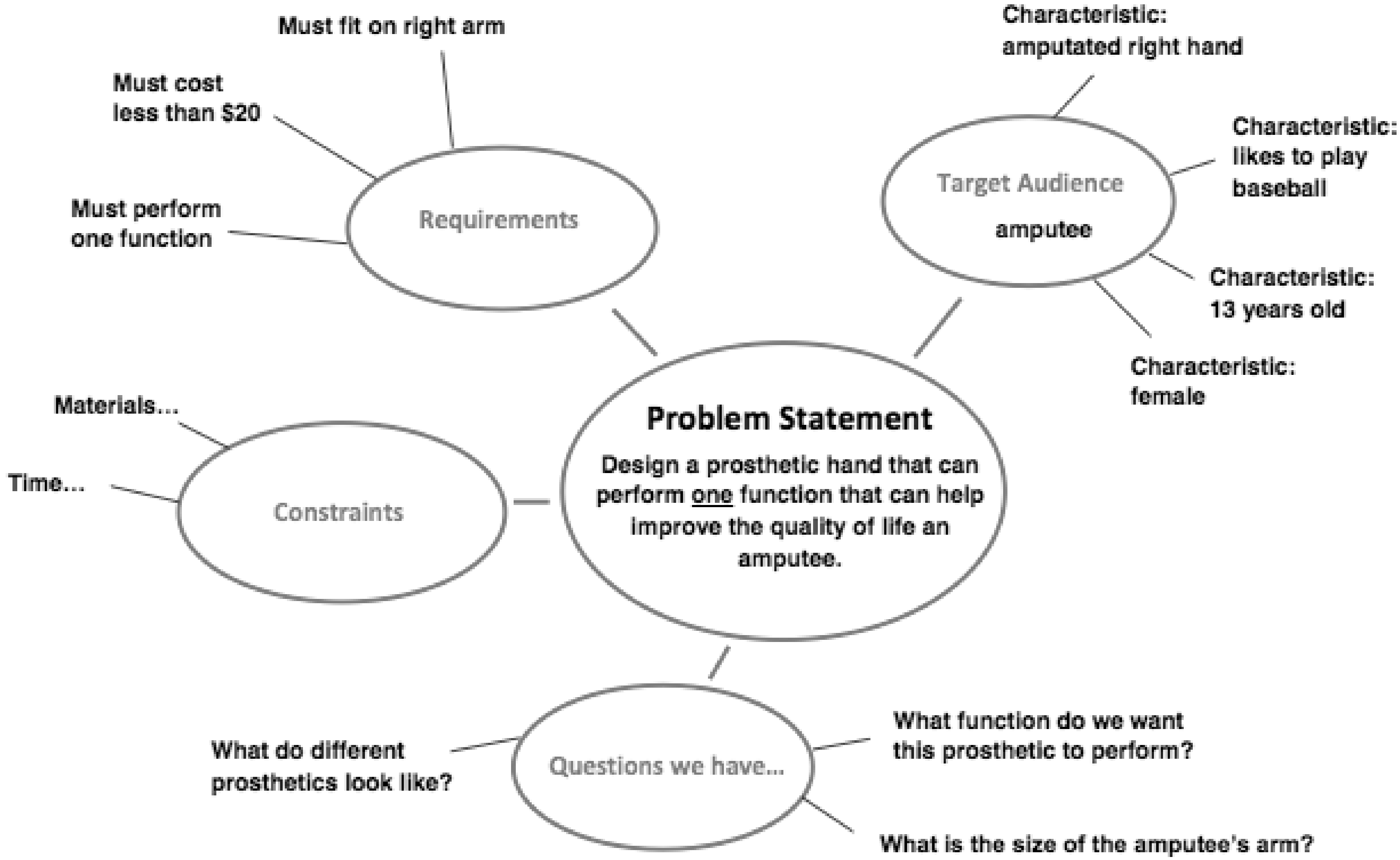
Idea Web Example



Design Step 2: Research the Problem Activity — Idea Web Example

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Brainstorming Guidelines

Focus on quantity	Capture as many ideas as you can!
Withhold criticism	No put downs!
Encourage wild ideas	Wild ideas lead to innovative designs!
Record all ideas	Write everything down as it comes out!
Combine ideas	Build upon the ideas of others!
Stay focused	Focus your ideas on the topic at hand!

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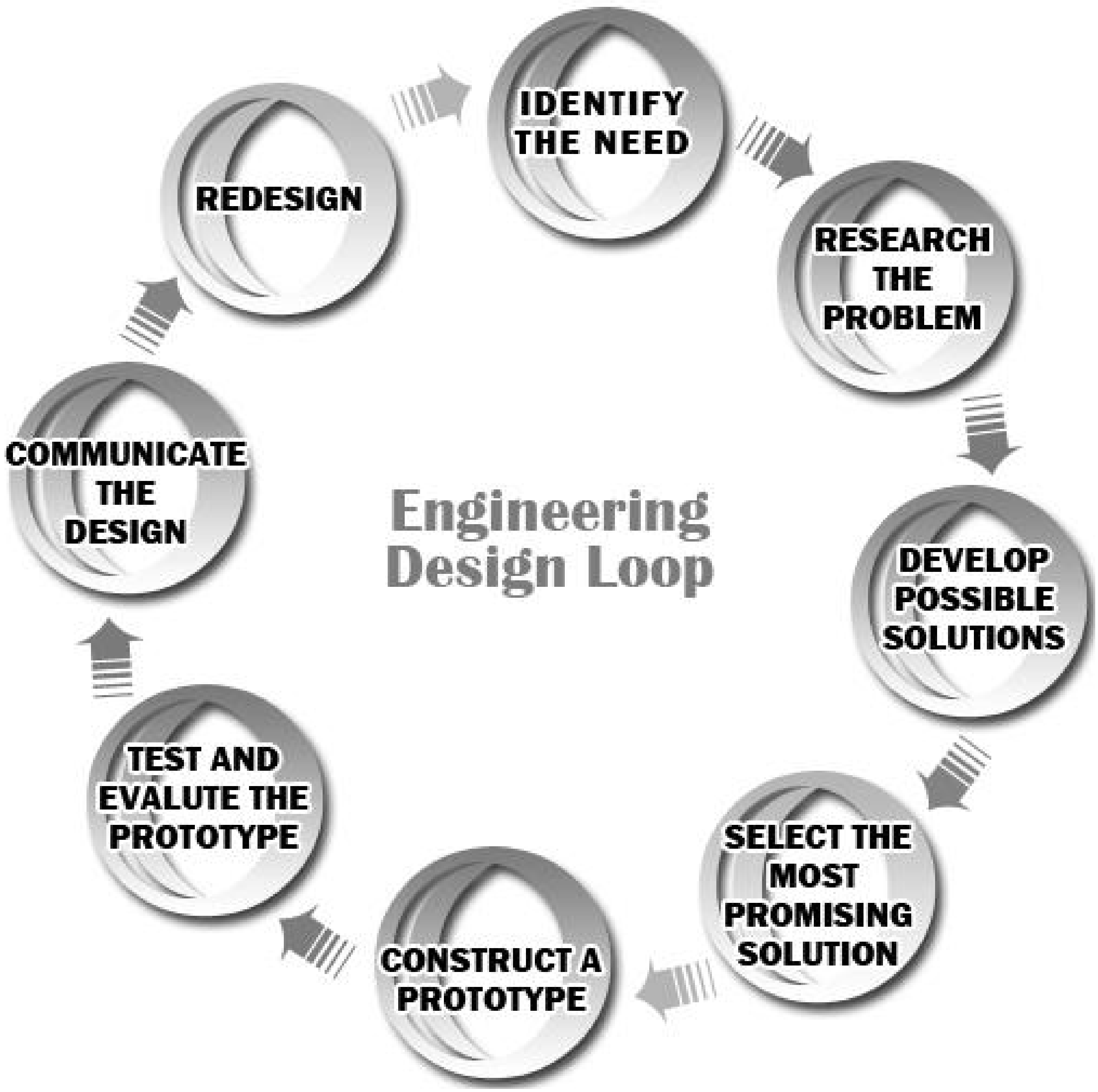
Engineering Design Loop

A specific and iterative set of steps engineers use to organize their ideas and refine potential solutions to engineering challenges.



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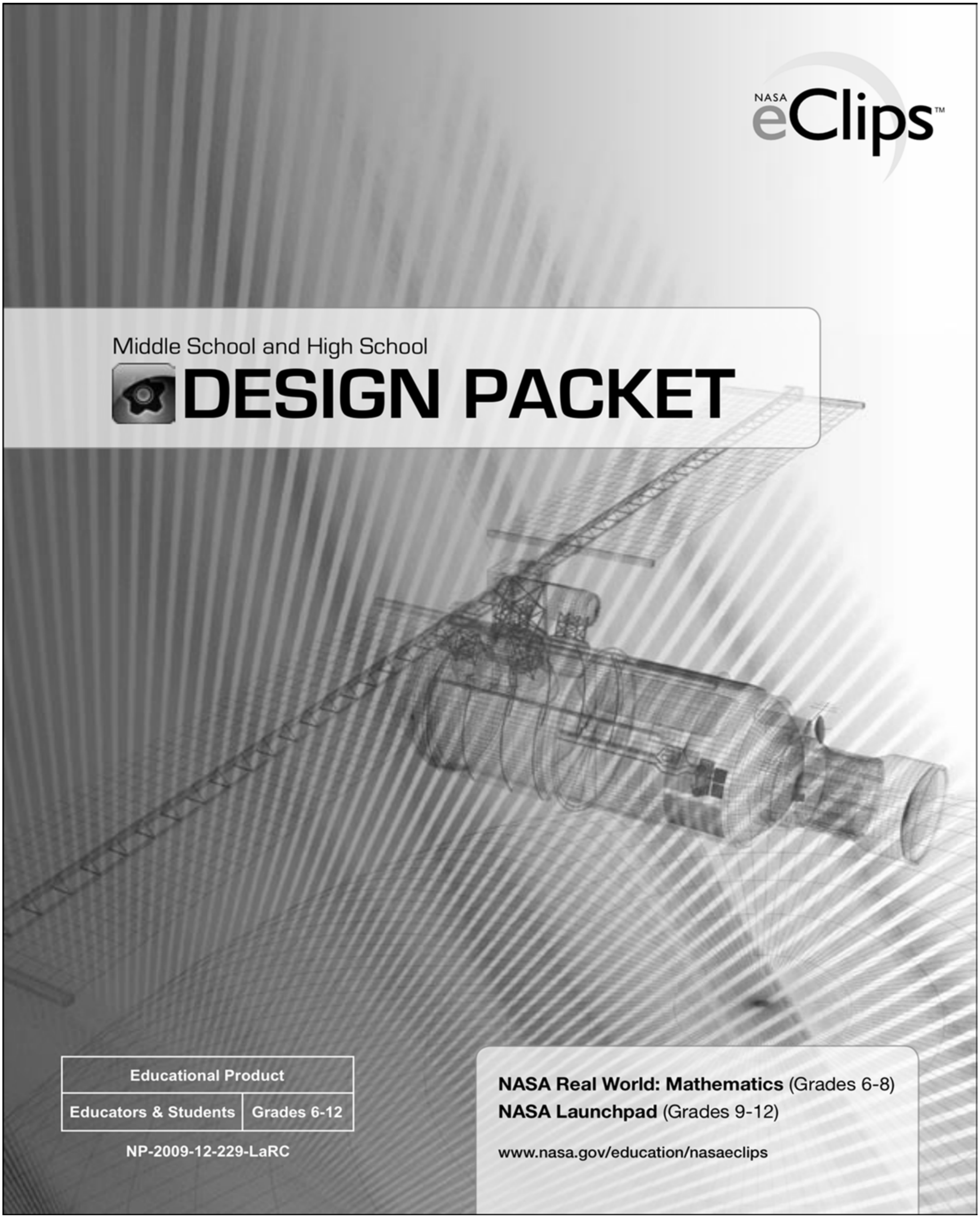
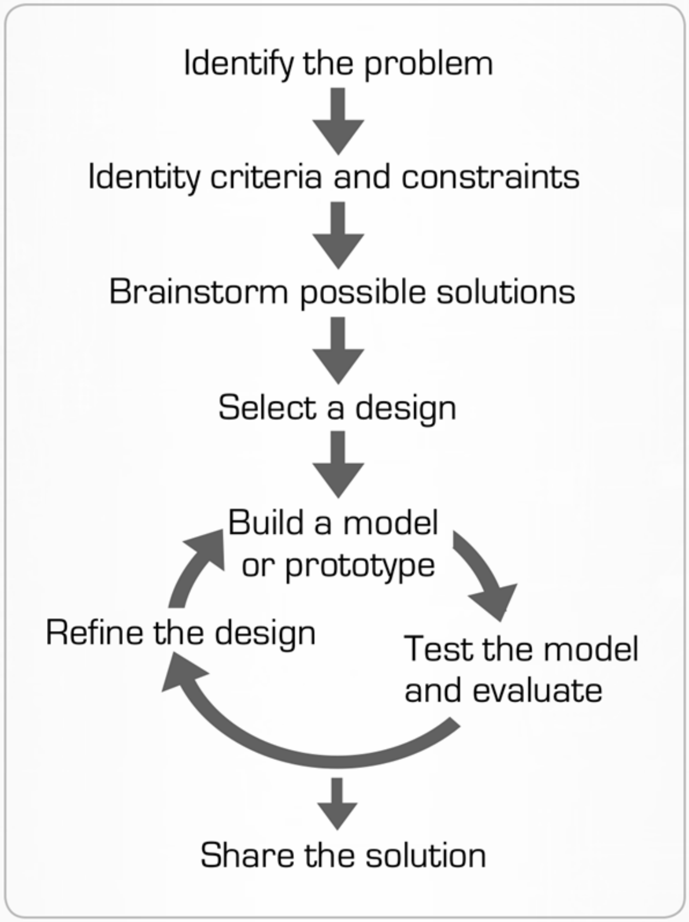

NASA eClips™
Middle School and High School
DESIGN PACKET
Educational Product
Educators & Students
Grades 6-12
NP-2009-12-229-LaRC
NASA Real World: Mathematics (Grades 6-8)
NASA Launchpad (Grades 9-12)
www.nasa.gov/education/nasaeclips

Design Process



Graphic of Design Process

Steps of the Design Process

1. Identify the problem.
2. Identify criteria and constraints.
3. Brainstorm possible solutions.
4. Select a design.
5. Build a model or prototype.
6. Test the model and evaluate.
7. Refine the design.
8. Share the solution.

Design Sheets

Steps 1 - 2

Middle School and High School Design Packet

Step 1: Identify the Problem

- State the problem clearly.

Step 2: Identify Criteria and Constraints

- Identify the conditions that must be met to solve the problem.

- Identify anything that might limit a solution, such as cost, availability of materials, safety.

- Be specific.

Design Sheets

Steps 3 - 4

Middle School and High School Design Packet

Step 3: Brainstorm Possible Solutions

- Consider what others have done to solve this problem and include prior research.

- Generate new ideas for solutions.

Step 4: Select a Design

- Choose two or three of the best ideas from the brainstormed list.

- Make a detailed sketch of each design.

- Label each sketch with dimensions and include the materials needed to build a model.

- Select one design to construct.

- Justify your choice by listing the reasons you selected this design.

Design Sheets

Step 5

Middle School and High School Design Packet

Step 5: Build a Model or Prototype

- Write a detailed procedure for building the model or prototype.

- List the materials actually used to construct the model.

- Follow your procedure and build the model.

Design Sheets

Step 6

Middle School and High School Design Packet

Step 6: Test the Model and Evaluate

Test

- Write a hypothesis about your design's performance during testing.
- Use an "If. . . then . . ." format. For example, "If the redesigned model has increased in size (change in the independent variable), then it will fall at a faster speed, (change seen in the dependent variable).
- Decide on a test for the model and try it out.
- Record the results of your tests.

Evaluate

- List the strengths of your design.
- List the weaknesses of your design.
- Discuss what changes, or compromises, in your design (if any) had to be made due to constraints.
- Decide if your design solved the problem identified in Step 1.

Design Sheets

Steps 7 - 8

Middle School and High School Design Packet

Step 7: Refine the Design

- Based on the results of your tests, make improvements on your design.
- Identify the changes that you would make.
- Give reasons for the changes.

Step 8: Share the Design

- Organize your findings. For example, you could make a poster, digital collage, PowerPoint presentation, or short video documentary.
- Present your findings to your teammates for feedback.
- Compare your design to those of your teammates.
- If you were to build this model again, what would you do differently and why?

Design Challenge Evaluation Rubric

Middle School and High School Design Packet

Group Members: ______________________________

____

Rubric Category	Score
Brainstorm to Identify the Problem and Constraints • The problem is identified and explained in detail. • All criteria and constraints are listed and clarified. • Possible solutions are listed from the brainstorming session. • The work others have done to solve the problem is included.	
Generate Ideas, Possibilities, and Design Choice • Two or three ideas are selected from brainstormed list. • Detailed sketches are created for the selected ideas. • Sketches are labeled with dimensions and materials for each component. • One design is selected to construct with reasons for the choice.	
Build the Model or Prototype • Detailed list of materials is included. • Detailed procedures are included and followed. • Materials are handled and stored appropriately. • Safety rules are followed.	
Test the Model and Evaluate • Hypothesis following an "if.., then…" format is developed for the design. • Strengths of the design are listed. • Weaknesses of the design or compromises of the design are listed. • Results are accurately recorded. • Data tables are complete and well organized. • The chosen design effectively addresses the identified problem.	
Refine the Design • Modifications to improve the design are based on test results. • Modifications to the design are documented. • Additional trials are conducted. • Reflections show great insight and understanding of process and goals of project.	
Share the Design • Presentation is well-organized. • Presentation covers all areas of the design process. • Presentation is clearly communicated (verbally or visually) with appropriate data, sketches, graphs or pictures. • Presentation includes contributions from all team members.	
TOTAL (out of 24 pts possible)	

4 (Excellent) = All criteria (procedures, steps, and details) are met or followed with rare mistakes.
3 (Good) = Most criteria are met with only a few mistakes.
2 (Fair) = Many criteria are not met and/or there are many mistakes.
1 (Poor) = Most criteria are not met.
0 (No effort) = No effort to meet criteria.

Engineering Design Process: Test & Improve

Practice modifying a device:
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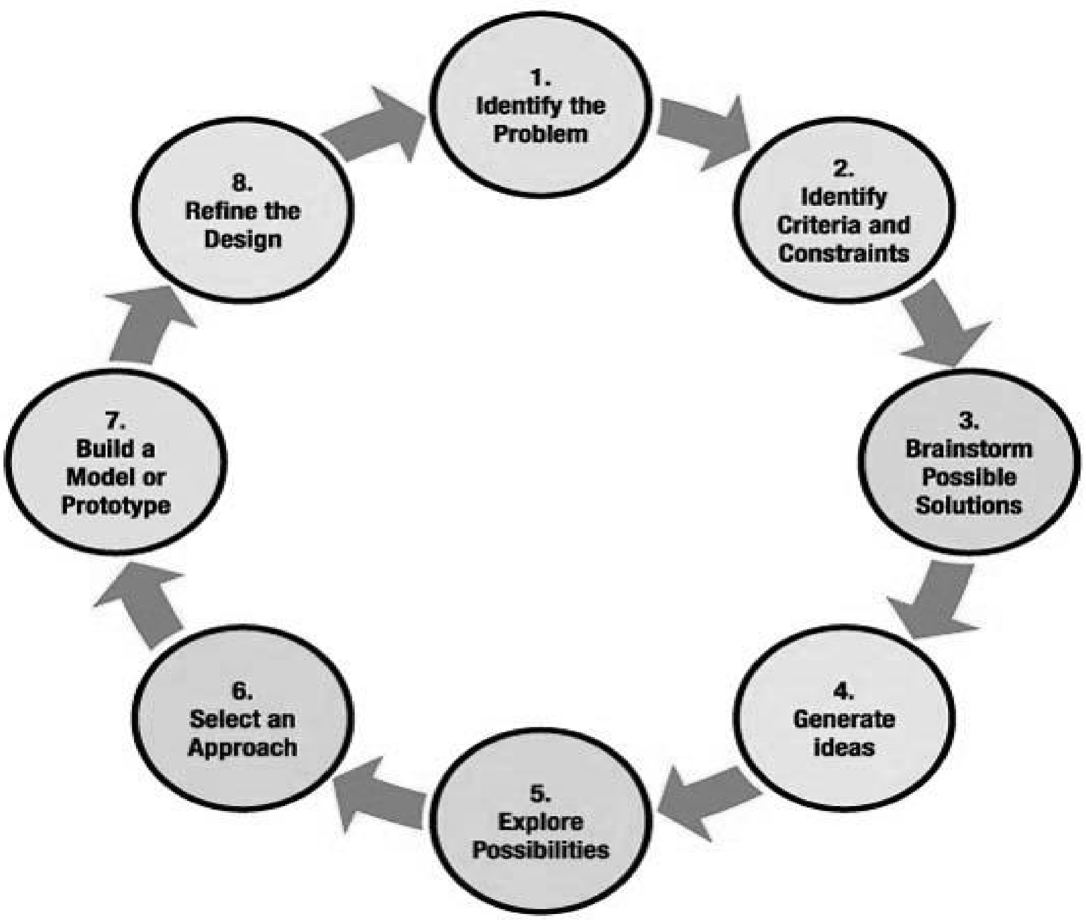

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Name ___________________________________ Period _______

Professional Response Letter

Writing Rubric

- **R**ole of the Writer: Who are you as the writer? A movie star? The President? A scientist?
- **A**udience: To whom are you writing? A senator? Yourself? A company?
- **F**ormat: In what format are you writing? A diary entry? A newspaper? A letter?
- **T**opic: What are you writing about?

R Role____

A Audience____

F Form____

T Topic____

RAFT Rubric

Points	10	5	0	Points Earned
RAFT	Satisfies all 4 RAFT components.	Satisfies 3 of 4 RAFT components.	Satisfies 2 or less of the RAFT components.	
Content	Exhibits knowledge of the bionic hand, includes important facts and information.	Exhibits some knowledge of the material.	No scientific facts included or major scientific inaccuracies.	
Writing Technique	Uses proper punctuation, spelling, grammar, and sentence structure.	Some mistakes.	Displays a lack of attention for rules of formal writing.	
Creativity	Displays originality, creativity and thoughtfulness.	Some attempts at creativity.	Predictable, little creativity.	
Presentation	Neat, easy to read, interesting graphics.	Neat, but lacks illustration.	Messy and hard to read.	
			Total	

Professional Response Letter Directions

Directions

1) You are the lead scientist on the DARPA Revolutionizing Prosthetics Team.

2) You and your fellow scientist have been building robotic hands for amputees as part of a United States Department of Defense Project for the past ten years.

3) You have received the letter below from the mother of one of your future patients who is to receive two of your latest robotic hands.

4) Read the letter then write a 'Professional Response' to the mother addressing her concerns while giving evidence of how your team has the expertise to help her son. You can include diagrams about how the hand will be attached or what the hand will look like.

5) Use the RAFT processes to help you focus your writing and be sure to include academic language related to the mechanics of hand movement in the development of the robotic hand. See the Rubric on the next page for specifics.

To: Dr. Geoffrey Ling, Program Manager
DARPA Revolutionizing Prosthetics Program
United States Department of Defense
http://www.darpa.mil/Our_Work/DSO/Programs/Revolutionizing_Prosthetics.aspx

From: Ms. Joanne Meyers
c/o Brad Meyers, Gen-3 Arm System Recipient
Houston, Texas

Dr. Ling,

Thank you for accepting my son Brad into your Robotic Arm Prosthetic Program. As you know from our application, Brad was involved in an industrial accident and subsequently had both his hands amputated. Prior to losing his hands my son was an avid musician playing the piano and guitar since he was a young child. What kind of hope can you give me that your Gen-3 Arm System will enable Brad to once again play the music that he so dearly loves? We want to be optimistic without getting our hopes too high. Thank you in advance for your thoughts on this matter. Brad and I are looking forward to meeting you and your team soon.

Cordially,

Ms. Meyers

Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas. (MS-LS1)

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