The Science and Biomechanical Engineering of Replacement Body Parts

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Science, Math & Engineering

• Science – study of the physical and natural world (what we can see and also what we can’t see)
• Math – study of logic, number, shape and arrangement
• Engineering – application of Math, Science and Technology to solve real-world problems
How do Scientists Solve Problems?

Scientific Method

Classic

1. Make Observations
2. Ask a Question
3. Form Hypotheses
4. Test Hypotheses
5. Analyze Results

Modern

1. Ask a Question
2. Do Background Research
3. Construct a Hypothesis
4. Test with an Experiment
   - Troubleshoot procedure. Carefully check all steps and set-up.
   - Procedure Working?
     - No
       - Analyze Data and Draw Conclusions
       - Results Align with Hypothesis
       - Communicate Results
     - Yes
       - Experimental data becomes background research for new/future project. Ask new question, form new hypothesis, experiment again!
   - Yes
     - Analyze Data and Draw Conclusions
     - Results Align Partially or Not at All with Hypothesis
     - Communicate Results

NJIT
New Jersey Institute of Technology

Center for Pre-College Programs
How do engineers solve problems?

Engineering Design Process

Identification of the Problem

Analysis of the Problem - Design Constraints

Research the Problem - Information Gathering

Brainstorm Alternative Design Solutions

Modeling “Best” Solution

Refine and Retest Model/Prototype

Testing and Evaluation Model/Prototype

Communicate Final Design e.g. Presentation

Identification of the Problem
Today’s Problem: Build a hand that works

• How does a human hand work?
  – Try it yourself
  – Research
    • Watch a video

• What do we know from science that can help us?
  – Physics
    • Mechanics
  – Biology
    • Anatomy
  – Chemistry
We are complex!!
Design Constraints

- Build a model to *learn*
- Start with something simpler: What do we really want to learn?

**How does one finger move?**

- Bones
- Joints (connections)
- Muscles
- Ligaments
- Nerves / Brain (controller)
Build a Model Finger

• Research: How does your finger move?
• Design a model using the materials provided. Make a sketch first.
• Build
• Test
• Share with another group – what researchers learn from each other.

How did the materials limit your design?
The Goal for Your Model Hand

Pick up an object and drop it in the basket
Build a model hand

- Palm
- Each child builds one finger
  - Fourth “finger” is the thumb
  - How to attach?

<table>
<thead>
<tr>
<th>Materials</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>9 Narrow Rubber Bands</td>
<td>Scissors</td>
</tr>
<tr>
<td>3 Coffee Stirrers</td>
<td>35 cm Nylon Cord</td>
</tr>
<tr>
<td>Cardboard</td>
<td>Centimeter Ruler</td>
</tr>
<tr>
<td>Tape and Scissors</td>
<td>Pen</td>
</tr>
</tbody>
</table>
Steps in Building Fingers

Diagram 1
- 3 equal cut pieces

Diagram 2
- Tape on inside
- Inside

Diagram 3
- Tape
- 5 cm long rubber band

Diagram 6
- Tape
- Straw
- 35 cm long string
- Inside finger and palm
- Nylon end
- Cut straw
Analyzing and Reporting Results

• What would you change for your next model?
• What factors might you have to consider if you were really building a working hand?
  – Anatomy / Physiology
  – Electronics Nanotechnology Innovation Center @ NJIT
  – Materials – weight / safe for human body / cost
  – Durability
  – Cost
  – Ease of maintenance / Cleaning
  – Aesthetics – manufactured skin Dr. Treena Arinzeh lab @ NJIT
  – Other …
Where is research taking us next?

- **Dexter and inflatable hands**
- **Video games to learn how to use prostheses**
- Tissue engineering: **Dr. Treena Arinzeh, NJIT**
- **NJIT research areas** in biomedical engineering
- **NJIT biomedical research centers**
- **NJIT Microfabrication Innovation Center**

Thank you for being part of our workshop. For further information on CPCP:
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Campus Tours

Google Earth view

https://earth.google.com/web/@40.74282357,-74.1769588,45.22207285a,761.33333367d,35y,-103.71896964h,44.99989893t,0r/data=CmUaYxJdCiUweDg5YzI1MzdkOThjMzk2Zjk6MHhiOTdjMjg3YTJlZjk1ZjQzGa69qg4UX0RAIRCglWpVi1LAKiJOZXcgSmVyc2V5IEluc3RpdHV0ZSBvZiB http://virtualhousing.njit.edu/

Big Bear Solar Observatory  San Bernardino CA

https://en.wikipedia.org/wiki/Big_Bear_Solar_Observatory
http://www.bbso.njit.edu/new_virtual_tour.html
http://www.bbso.njit.edu/new_tour/h_alpha.html

Inside the dorms  http://virtualhousing.njit.edu/