The following steps will walk you through the Chapter Project. Use the hints and detailed directions as you guide your students through design, construction, presentation, and reflection.

**Chapter Project Overview**

Designing a prosthesis will allow students to see the relationship between various desired characteristics in a design and the materials available to execute it. At the same time, they should come to appreciate how difficult it is to imitate, even crudely, the functionality of the human hand.

The hand was chosen for this project because, compared to other appendages, it is relatively easy to mimic and fabricate. The choice of the hand will also make it possible to set specific and clear criteria for evaluating students’ models.

This project should also provide some insight into the role that materials and fabrication play in determining the feasibility of an idea.

To introduce the project, lead a discussion about some of the technological advances that can restore certain functions: glasses, false teeth, hearing aids, implanted joints, and prosthetic limbs. Discuss the kinds of things that would be important to be able to do with a hand prosthesis, such as lifting, buttoning a coat, tying a shoe, and so on.

You may also choose to begin by showing a model of a hand prosthesis that you prepared ahead of time.

Distribute the Chapter Project Overview and review the project rules. You may also want to hand out the Chapter Project Scoring Rubric, so students will understand what is expected of them.

Organize the class into small groups. Make sure students understand what is expected of each member of a group. For example, you may want each member of a group to develop a design before meeting with other members.

Point out that as they progress through the chapter, their design will be reviewed to be sure it meets design requirements.

Next, lead a brainstorming session to get the students thinking about what needs must be met to create a model prosthesis. Treat the brainstorming sessions as guided creativity. Interject ideas only when necessary to help guide each group along a productive path.

Once the brainstorming portion is complete, introduce a method for selecting the best design. The evaluation phase should include a defined set of criteria regarding the functionality of each model. The model prosthesis should be able to grasp, lift, and release; it must be activated by a pulled cord or string; it must spring back when the cord is released.

Set a deadline for the project presentation and some interim dates, such as at the end of Sections 1, 2, 3, and 4 for checking students’ progress. Have students record the dates on their Project Timeline.

A sample timeline, by task, is shown below.

<table>
<thead>
<tr>
<th>Task</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examine the structure and functions of the human hand</td>
<td>15 minutes</td>
</tr>
<tr>
<td>Experiment with various objects and decide what type of device could best meet the design requirements</td>
<td>3 hours</td>
</tr>
<tr>
<td>Develop ideas for construction</td>
<td>3 hours</td>
</tr>
<tr>
<td>Build the device</td>
<td>5 hours</td>
</tr>
<tr>
<td>Prepare presentation</td>
<td>2 hours</td>
</tr>
<tr>
<td>Deliver presentation</td>
<td>10 minutes</td>
</tr>
</tbody>
</table>
**Materials and Preparation**

Tools available should include a vise; bendable coat hangers; heavy cardboard; several types of pliers, tweezers, tongs, chop sticks; cutting and bending tools for wire; wire; cord or string; sandpaper; files and saws for plastic and wood; rubber bands; spring-loaded clothespins; large clips for holding bags closed. A variety of tape products might be used, including duct tape, fiberglass reinforced packing tape, and adhesive tape. A combination of rubber bands can be used to provide the return force against the string or cord.

**Troubleshooting**

The most likely source of problems will be in getting the functionality that is wanted. Hinges or pivots are harder to make workable than it appears at first. If a working hinge is taken from another device, it will probably make things easier. Parts from broken toys will often be useful.

**Keep Students on Track**

**Section 1**

Talk with each group during its initial meeting. Make sure they take one another’s sketches and ideas seriously. At this point, students should think about the materials they will use for their models.

Distribute Chapter Project Worksheet 1. Make sure students understand they will need to use this worksheet as they read the chapter and learn more about how the body works, especially the muscular system.

**Section 2**

Check to see that student groups have chosen a design for their models, and review their material lists.

Look over the Project Folder to check individual designs. You may want to score individual designs as well as the collaborative design.

**Keep Students on Track**

**Section 3**

Review the prototype built by each group by using the group’s checklist of criteria. Examine the model for major flaws or possible problems. If any exist, have students work on solutions to be shown to you and approved before the final build. Distribute Worksheet 2.

**Keep Students on Track**

**Section 4**

Models should be built and tested and any last-minute modifications made. Students should be planning their presentation/demonstration of their hand prosthesis models.

**Chapter Project Wrap Up**

As you review each group’s final model, you may wish to have the members “talk you through” the presentation/demonstration. Make suggestions for organizing the presentation. When appropriate, encourage some students to take a greater role in presenting the model.

Provide class time for group presentations. Allow each group to present its model and explain its features. Encourage other students to ask questions about the model and its features.

After presentations have been made, discuss with students which models seemed to meet the requirements in the most effective and/or creative way.

Encourage students to evaluate how well they accomplished the assignment, including how well the final model matched the final design the group had agreed upon. Invite students to make suggestions about what they think would have made the project better.

**Extension**

Students might want to do more research on prosthetics and gather articles about people their age who have returned to active lives because of the prostheses available to them.
Design and Build a Hand Prosthesis

How can you make a model that simulates the functions of a human hand? In this project, you will work in a group to design and build a prosthesis that can perform several functions of the human hand.

First, you will make sketches of your own design for a hand prosthesis. Then you will meet with your group to review all members’ designs and agree on a single design for the prosthesis. As you and other group members learn more about the human body’s muscular system, you may decide to modify your design. At the end of the project, your group will present your finished prosthesis to the class.

Project Rules

- Your group will begin by researching the functions of the human hand and thinking about existing devices that can be used to simulate the functions of grasping, lifting, and releasing. Your group should also review the additional design criteria: the prosthesis must be activated by a pulled cord or string; and it must spring back when the cord is released.

- Using this list of requirements, your group will brainstorm some designs for a model. Then each group member will create sketches of his or her own version of a model. Keep any sketches you make in a Project Folder. Show your sketch or sketches to your teacher and discuss your ideas for a prosthetic hand at the end of Section 1.

- With your group, review one another’s ideas and sketches. Come to a consensus (agreement) on a design for the hand prosthesis model you want to build as a group.

- Choose the materials for your model—the real-life version of the design you have drawn on paper. By the end of Section 2, you will be required to submit to your teacher a list of all the supplies you will need to complete this task.

- Test the completed model to find out if it meets all of the criteria for the prosthesis—it must grasp, lift, and release; it must be activated by a pulled cord or string; and it must spring back when the cord is released. Make modifications to your model if needed. Discuss any design modifications with your teacher at the end of Section 3.

- With your group, make any needed modifications to your model. Then prepare a presentation and demonstration to the class of your completed prosthetic hand. As part of the presentation, you will also explain how you chose your final design, what materials you used, any special features of your model, and how it meets the design criteria.
Bones, Muscles, and Skin  •  Chapter Project

Project Hints

■ Read reference materials to find information about prosthetic hands. Also research the structure and functions of the human hand. Observe how a human hand grasps, lifts, and releases objects.

■ As soon as possible, begin collecting materials you will use to build the hand prosthesis.

■ Work closely with other members of your group, and listen to their ideas. You might find that someone in your group has just the right idea to make your own design a great deal better.

■ Don’t be afraid to suggest changes to your group’s design if it doesn’t seem to function as expected after you’ve begun construction.

■ Make sure your model meets all of the design requirements.

■ Try to make your model and presentation unique as well as accurate and informative.

Project Timeline

<table>
<thead>
<tr>
<th>Task</th>
<th>Date Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Complete design and sketches for Worksheet 1.</td>
<td></td>
</tr>
<tr>
<td>2. Agree on a group design for prosthetic hand.</td>
<td></td>
</tr>
<tr>
<td>4. Construct model.</td>
<td></td>
</tr>
<tr>
<td>5. Test model to be sure it meets requirements.</td>
<td></td>
</tr>
<tr>
<td>6. Make any necessary modifications to your model.</td>
<td></td>
</tr>
<tr>
<td>7. Prepare class presentation/demonstration.</td>
<td></td>
</tr>
<tr>
<td>8. Deliver class presentation/demonstration of model.</td>
<td></td>
</tr>
</tbody>
</table>
Design and Build a Hand Prosthesis

This worksheet will help you get started creating a design for your prosthetic hand.

**Model Requirements**

1. What activities must the model hand prosthesis perform?
   ________________________________________________________________
   ________________________________________________________________

2. What are some key features that must be incorporated into the design?
   ________________________________________________________________
   ________________________________________________________________

3. How will your group choose the best design?
   ________________________________________________________________
   ________________________________________________________________

**Planning the Design**

4. Describe the model you think your group should build.
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________

5. What materials will you need to build this model?
   ________________________________________________________________
   ________________________________________________________________
   ________________________________________________________________

6. In the space below, sketch a model of a hand prosthesis that your group could build. Keep the sketch in your Project Folder. Take this worksheet and your sketch to your group meeting. Discuss your ideas with group members.
Refining the Model

Now that you have learned more about how the body works, you may want to make some changes to your model prosthesis. This worksheet will help you organize your thinking about the changes that are needed. Use a separate sheet of paper if you need more space.

1. List the functions the model can perform well and consistently.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. List the functions the model cannot perform or performs poorly or inconsistently.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

3. Are failures of the model due to the design or to the materials used?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

4. What features or modifications can be used to improve the model?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

5. On a separate sheet of paper, sketch a revised model that your group can build. Keep the sketch in your Project Folder. Take this worksheet and your sketch to your group meeting. Discuss your ideas with group members. Then make the necessary changes to your model.
### Individual Sketches and Designs

- **Level 4**: Student makes sketches that show originality of design and a thorough understanding of the criteria that the model hand prosthesis must meet: it is activated by a pulled cord or string; it springs back after cord/string is released; and it mimics three activities of the human hand—grasping, lifting, and releasing.
- **Level 3**: Student makes sketches that show some originality of design and a good understanding of the criteria that the model hand prosthesis must meet.
- **Level 2**: Student makes sketches that show adequate design and some understanding of the criteria that the model hand prosthesis must meet.
- **Level 1**: Student makes sketches that show an incomplete or inaccurate understanding of the criteria that the model hand prosthesis must meet.

### Constructed Model of the Prosthesis

- **Level 4**: Model is well constructed and meets all of the required criteria. The hand is activated by a pulled cord or string. The hand springs back after the cord/string is released. The prosthesis mimics three activities of the human hand—grasping, lifting, and releasing.
- **Level 3**: Model is constructed adequately and meets at least three of the required criteria listed in Level 4.
- **Level 2**: Model is somewhat sloppily constructed and meets at least two of the required criteria listed in Level 4.
- **Level 1**: Model is poorly constructed and meets only one of the required criteria listed in Level 4.

### Presenting the Model to the Class

- **Level 4**: Student makes a thorough and interesting presentation that includes a clear, accurate explanation and demonstration of how the model meets design criteria.
- **Level 3**: Student makes a thorough presentation that includes a satisfactory explanation and demonstration of how the model meets design criteria.
- **Level 2**: Student makes a presentation that includes a partial explanation and demonstration of how the model meets design criteria.
- **Level 1**: Student makes a presentation that includes an incomplete and/or inaccurate explanation of how the model meets the design criteria.

### Participating in the Group

- **Level 4**: Student takes a lead in planning, constructing, and presenting the model.
- **Level 3**: Student participates in most aspects of planning, constructing, and presenting the model.
- **Level 2**: Student plays a minor role in planning, constructing, and presenting the model.

### Bones, Muscles, and Skin

- **Chapter Project Scoring Rubric**

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**Name ____________________________ Date ____________________ Class ____________**