INTRODUCTION TO MECHANICAL SYSTEMS

TASK DESCRIPTION

Studio I is a mechanical dissection of various electric toothbrushes conducted in a group of two. The physical dissection and investigation are to be performed in studio while the report will be written outside of the studio. The task involves the following: dissection of an Oral-B CrossAction Power electric toothbrush with replaceable battery; inspection of an Oral-B CrossAction Power electric toothbrush with rechargeable battery; and inspection of two Crest SpinBrush PRO-CLEAN electric toothbrushes with replaceable batteries (one will be pre-dissected). The task is to inspect them, sketch them, determine how they operate, and reassemble them so they work.

Only the Oral-B CrossAction Power electric toothbrush with replaceable battery will be fully dissected in the lab. The two un-dissected toothbrushes are to only have their battery covers and head assemblies removed. Table 1 summarizes the materials and tools that will be used in this lab.

<table>
<thead>
<tr>
<th>Table 1 - Lab Materials (Prices as of August 2011)</th>
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<tbody>
<tr>
<td>Oral-B CrossAction Power toothbrush with replaceable battery</td>
</tr>
<tr>
<td>Oral-B CrossAction Power toothbrush with rechargeable battery</td>
</tr>
<tr>
<td>Crest SpinBrush PRO-CLEAN toothbrushes (one assembled, one dissected)</td>
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<td>Screwdriver, Ruler, Tape</td>
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The studio deliverable is a group report due at the beginning of studio next week. However, access to the toothbrushes is limited to the assigned studio hours this week. It is therefore necessary to utilize this time for physical inspection and sketching while the report is to be written outside of studio. It is critical that all pertinent information is collected in lab notes in order to facilitate report writing. This includes rough sketches with dimensions, descriptions of how the brushes operate, etc. Keep track of how parts fit together and relate to each other as the brushes are disassembled. This will allow proper reassembly of the device. Make multiple sketches of the device in various stages of disassembly. Digital photos are not acceptable in the written report, but may be useful in reassembling the toothbrushes and writing the report. Utilize the tape to label parts or tape them down in the assembly order so as not to lose them. Be certain that all report discussion questions have been reviewed and addressed before leaving studio so as to be certain that all pertinent information was gathered.

Care must be taken during disassembly as the device needs to be reassembled and properly operate for completion of the studio - other students will need to dissect the device.
PROCEDURE FOR MECHANICAL DISSECTION

Dissection Guide: Consider the following during dissection:

- Keep a good record of what is being done.
- Keep track of all the parts and periodically update the bill of materials during dissection.
- Be as specific as possible with function and material.
- Be certain that the functionality of all internal parts are understood.

Dissection Steps:
These refer to the Oral-B toothbrush with replaceable battery, unless otherwise noted. READ ALL THE INSTRUCTIONS AND THE TOOTHBRUSH INSERTS BEFORE STARTING THE DISSECTION.

1. **Operate the device.**
   Observe the sequence of operations that make it work. What indicates how to operate the device? Are they clear?
   Observe how it works.
   Sketch the brush / brush head motion(s)
   List the customer needs and engineering specifications.
   List the sequence of operations and determine the overall function, required inputs, and outputs of the system (i.e., treat the device as a Black Box).

2. **Take off the brush head carefully.** Do not disassemble the brush head.
   How was the brush head removed?
   Was it easy to remove?
   Is the brush head meant to be replaceable? Is this obvious without consulting the directions?

3. **Operate the device without the brush head attached.**
   What is observed?

4. **Remove the bottom of the device by unscrewing it.**

5. **Remove the battery.**
   Observe how the device indicates which way to put in the battery.

6. **Remove the battery/motor subassembly.** Do not disassemble the subassembly.
   How was the subassembly removed?
   Why are the snap fits located where they are?

7. **Put the battery back in the battery/motor subassembly.**

8. **Operate the subassembly.**
   Discuss observations about its operation. What physical phenomena are utilized to achieve device functionality?

9. **Remove the rocker switch.**
   What happens? Why? How is this use of the physical properties of the material interesting?

10. **Remove the battery.**
11. **Bend the motor out a bit to get a good look at it.** Do not disassemble the subassembly.
What markings are on the motor?
Notice the lack of wires - why? What replaces them? Why?

12. Remove the metal rod. Do NOT remove the white plastic part from the rod.
How was the metal rod removed from the housing?

13. Now compare the drive mechanism of the Oral-B toothbrush to that of a Crest SpinBrush PRO-CLEAN toothbrush.

Do NOT disassemble either the dissected or undissected Crest toothbrushes. Only remove any covers or brushes to observe their workings.

Operate the Crest electric toothbrush and observe its operation. Observe the operation of the subassemblies provided. Non-destructively take apart the complete Crest toothbrush. Untwist the Crest toothbrush head to remove and replace it. A schematic of the drive train of the Crest toothbrush is shown in Figure 12 of US patent #6,932,216. For the purposes of this studio, the drive train includes components 200, 202, 208, 206, 210, 222, 220, 226, 224, 232, 250, 230, 234, 252, 253, 244, 240, 260, 246, 254, 262, 256, and 164.

Observe its operation to verify that it is the same motion as the replaceable battery version. What differences do exist between the two toothbrush variants? Why are they needed?
How does the toothbrush recharge the battery? What physical phenomenon is at work?
What design feature ensures that the toothbrush sits properly in its charger?
Reassembly: Put the toothbrushes back together so that they operate correctly. Note that the Oral-B toothbrush goes together easier with the battery removed.
MECHANICAL DISSECTION DELIVERABLES

Deliverables due at the end of this studio
  1. Reassembled, working products
  2. Tools
  3. Cleaned up work area

Deliverables due at the beginning of studio next week
  1. Two printed copies of one report per group containing nominally dimensioned sketches, explanations, and observations. Reports should include a maximum of 4 pages of writing, plus any number of figures and tables. This is a group report; all members of the group should be named on the title page. The report hard copies must be printed before arriving to studio. In addition, email a PDF copy of the report to the section TA before arriving to studio. Specific details for the report are as follows:

MECHANICAL DISSECTION ANALYSIS REPORT

Text Style: Describe the toothbrushes and how they operate rather than what was learned by doing the assignment. Use 3rd person voice instead of the usual 1st person voice. Be straightforward in the writing. Leave out any opinions on what a wonderful product it is or what a terrific job the toothbrush designers did unless specifically asked. Format the report as a discussion of the toothbrushes rather than a story-line of what was done in the lab.

At a minimum, include one paragraph on function, one on materials, one on assembly processes, and one or two on the additional questions asked to be addressed. Be sure to reference and discuss sketches and bill of materials. As an example, look at the table reference on the first page of this document. Every figure and table must have a caption. Figure captions are located centered below the figure while table captions are centered above the table. Every figure or table must be cross-referenced within a discussion paragraph somewhere before it appears in the report. Notice how Table 1 is cross-reference in the paragraph just before it appears. Follow the report format in Appendix A.

Discussion Content: Describe how the Oral-B toothbrush operates: Describe how its subassemblies operate together to produce the tooth-brushing action. Describe the interactions and interfaces between the subassemblies. Suggest how the Oral-B toothbrush subassemblies are assembled. Be sure to consider the symmetry/asymmetry of the components. Suggest how the subassemblies are assembled into the final assembly. Suggest ways to modify the product’s design to improve the assembly processes.

Suggest ways to reduce the number of components and subassemblies. Are there screws in the Oral-B toothbrush? Are there screws in the Crest toothbrush? Discuss.

How often will the Duracell AA MN1500 battery in the Oral-B toothbrush need to be replaced (days)? Is this a reasonable amount of time? Compare your answer to the battery change interval given in the Oral-B toothbrush insert. Discuss. (Perform calculations using equations, as well as finding the answer in a look up table or figure - discuss the two answers and their accuracy.) See the pamphlets for both the rechargeable and non-rechargeable Oral-B brushes.
Compare the drive mechanism of the Oral-B toothbrush that you dissected to that of the Crest electric toothbrush. Do both toothbrushes produce the same brush / brush head motion(s)? Discuss the difference in the drive trains and the resulting brush motions. Which is superior from a manufacturing/assembly standpoint? Which do you consider a better design? Illustrate your discussion with figures.

Compare the two Oral-B toothbrushes (replaceable battery and rechargeable battery). When can the consumer expect to break even with the more costly toothbrush given the price increase for the rechargeable toothbrush and the cost to replace batteries? Base the answer on the battery life calculations and estimates of toothbrush life. Is it worth the extra initial cost for the consumer? Discuss the advantages and disadvantages of the two types of toothbrushes.

Figures:
• An isometric view drawing of the undissected Oral-B toothbrush with replaceable battery, showing as much detail as thought appropriate. Utilize phantom view to show internal parts, as necessary.
• Do isometric drawings of at least two other interesting parts or subassemblies of the Oral-B toothbrush with replaceable battery.
• Other figures as needed to support explanations.
• All figures should follow good drawing practice as taught in an Engineering Graphics course.
• All figures should be hand-drawn and nominally dimensioned.

Bill of Materials (BOM): Complete a bill of materials table for the Oral-B toothbrush with replaceable battery. Use a font size and landscape or portrait formatting to fit the table on one page but do not compromise readability. Be as specific as possible in identifying materials. For example, state the kind of plastic polymer with as much detail as the dissection provided, not just that it is plastic. If uncertain, tag the candidate material with “(?)” on the BOM. Be professional. Remember to organize your BOM by subassembly.

Special thanks to Prof. Will Durfee of the University of Minnesota, for the concept of this exercise and for some of the materials contained within.

Please submit 2 copies of this report.
Appendix A

Suggested Report Format for the Introduction to Mechanical Systems Project

As you prepare your report, you should first review the Guide’s instructions. Then you should determine which format sections are of most importance in this project report.

For the dissection studio project, you are asked to examine and analyze a device(s) or system(s). You should format your reports to present the device(s) you examined and to evaluate its good and bad points, as reflected in the suggested outline below:

Abstract
This is a summary of the entire report condensed into a single paragraph. It should include a report introduction, the most important points of discussion, and a brief summary of the most important conclusions. This paragraph should be able to be read alone as its own mini-report.

Introduction
Introduce the dissection and what will be discussed. Present what is understood to be the device requirements and basic functionality of an electric toothbrush.

Device Overview
Present and discuss the devices that were examined. Present and describe the drawings of the device(s).

Discussion
Evaluate the devices, explaining their strengths and weaknesses. Suggest changes to the design to address weaknesses. Address other discussion questions as required.

Conclusion
Present any conclusions that result from the presented discussion. This includes which devices have better designs and why. Also, which devices achieve the design functionality and requirements the best and at the best value.

Submit 2 printed copies of this report and email a PDF copy to the TA.