PROJECT I – REVERSE ENGINEERING

Reverse engineering is a method used to understand how a device works. It involves the analysis of the structure, function, and operation of the device. Often, reverse engineering requires full disassembly of the device to understand each component (or part). It is an industry best practice that can lead to both incremental improvements and complete product redesigns. Virtually every engineering organization performs reverse engineering to a certain extent. Reverse engineering of everything, other than software, is completely legal in the US and most countries, if the item being reverse engineered was lawfully obtained. Software may be reverse engineered unless it is forbidden by an end user license agreement. Patents require public disclosure of the invention in the patent. Therefore, patents can be an excellent resource to understand a product design without having to physically disassemble the product. Other publicly available information about a product, material, or theory of operation can also be legally used.

In this class, we will reverse engineer a *7.4 in. Light Duty Staple Gun* to understand its operation and propose an improvement to its function. This is a typical high-volume consumer device that a mechanical engineer might design. It has been designed by real engineers to serve a real purpose.

The Task

1. Obtain the device from your TA.
2. Prior to disassembly, your group should identify at least six important customer requirements for the device and how the provided product performs relative to these requirements. You are encouraged to use publicly available information (online discussions, reviews, etc.) about customer requirements and the performance of such a device. Document your observations and include them in your analysis of a recommended improvement. **Template:** *Customer Requirements*
3. Disassemble the device as much as possible and in a way that allows you to understand every part and its dimensions, while documenting the process. Some parts may be glued, welded, or riveted together. In this case, use the best approach you can to separate them without losing the ability to measure the original dimensions. **Template:** *Reverse Engineering*
4. Create a bill of materials (BOM) that lists **all parts** in the assembly (including standard fasteners, wires, etc.). This BOM (in conjunction with the solid models and 2D drawings you provide) should provide enough information to allow us (or someone unfamiliar with your product) to find and order every component in the device (include materials information for each component). Your BOM should also summarize the manufacturing processes used to make the product. These processes could include machining, injection molding, gluing, welding, etc. For non-unique components (such as standard fasteners, wires, packaging, etc.), give enough information (dimensions, etc.) on the BOM for someone to know what part to buy (e.g., *10-32 x 1/2" pan head stainless steel machine screw*). Make sure to note which standard components are metric and which are English units. **Template:** *BOM*
5. Measure the 20 most significant unique mechanical components of the product. Note that this device is an assembly of subassemblies and when you start taking it apart, some subassemblies may have many intricate parts in them. Generate a complete 3D solid model of each of the 20 most significant components. You will need images of the solid models for your report.

6. For each of the 20 most significant components for which you generated a 3D model, create a complete 2D engineering drawing that includes the 3—6 most important dimensions related to how the part interfaces with the assembly.
7. Generate a complete solid model assembly of the entire device.
8. Generate a single exploded assembly diagram of the entire device, showing how it is most likely assembled. Each of the parts on this exploded assembly diagram should be labeled to reference the BOM.
9. If possible, put the device back together and see if it still works properly.

The Deliverable

Your group must prepare a formal reverse engineering report with the following content in the order provided:

1. Cover Sheet (3 Points)
   a. Title and date
   b. Group number
   c. Name and email address of each team member
   d. Table of Contents with page numbers referenced

2. Photo of device overlaid with 3D solid model image (12 Points)
   a. A single digital photo of the actual product scaled to fit the page
   b. Superimpose your 3D solid model over the digital photo. Use a semitransparent rendering of the model and scale the model to fit the actual photo such that the model and the actual device image align.

3. Project Plan (30 Points)
   a. Complete Project Plan **(template)** indicating a sequenced list of tasks, detailed task descriptions, owners, planned task start and finish dates, important milestone dates, actual task start and finish dates, dependencies, critical path(s), weekly status snapshots, estimated hours (per task or student and total estimated for group), and actual hours (per task or student and total for the group).
   b. Gantt Chart covering the entire project timeframe. The Gantt Chart must include tasks, owners, planned start/finish dates, actual start/finish dates, dependencies, and weekly snapshots.

4. Bill of Materials (BOM) (15 Points)
   a. Bill of materials (**template**) listing all parts in the device, including screws, gaskets or other fasteners, packaging, etc., and manufacturing processes used to make the product. **Include all parts** of the device (not just the 20 most important components).
   b. Number the parts so that they may be referenced in other portions of the report.

5. Exploded Assembly Diagram (15 Points)

a. A detailed, 3D exploded assembly diagram of the device. Each item in the exploded assembly should have a reference number relating it to the bill of materials and drawings (where applicable). **Note** that you do not need to include packaging materials in the exploded assembly.

6. Detailed Device Description (45 Points)

a. Reverse engineering process (**template**), including a detailed description of how the device functions (how it works in general and how the important components interact with one another). Include pictures of the system that display moving parts involved in the steps you describe. Sufficient detail should be provided such that the reader could recreate the device without any additional information.

b. A design structure matrix (DSM).

c. Figures of the solid models created of each of the 20 most significant components, with part numbers.

d. You will be evaluated on the quality and level of detail and engineering understanding demonstrated in this section of the report.

7. Engineering Drawings (30 Points)

a. 2D engineering drawings of the 20 most significant components of the device, each with 3—6 of the most important reference dimensions. Include GD&T symbols.

b. Because all details are in the solid model, you don't need to provide every part dimension. Fabricators can import and use your solid model file. Typically, providing 3—6 dimensions on the drawing, such that key parameters can quickly be verified for consistency in the solid model, is sufficient. The best practice is to select dimensions that are (a) easy to measure and (b) most critical to the device functionality. Where appropriate, use the geometric dimensioning and tolerancing symbols and conventions that you learned in MECH 201 to correctly show what is critical and how critical it is.

8. Competitive Analysis (15 Points)

a. A description of the research you performed to identify other designs of similar products and what you learned from them. This should include a list of any patents studied and links to any articles read online.

b. Use multiple types of data sources (reviews, product data sheets, patents, technical papers, etc.) and provide multiple examples of each type of data source.

9. Product Improvement (90 Points)

a. A full Quality Function Deployment (QFD) analysis (**template**).

b. Identify the target customers for your improved device.

c. Show the customer requirements developed (**template**), how these requirements were determined, and their relationship to the target customers for your improved device.

d. List 2—4 competitors to your device and how they compare to your device in meeting customer requirements. You don't need to buy competing devices. You can use any publicly available information to make your comparisons.

e. List the specifications that your device must meet based on the requirements previously identified and how the specifications link to the requirements.

f. Identify tradeoffs between specifications.

g. Establish specification targets.

h. Generate a minimum of three improvement concepts (***optional*** **templates**).

i. Evaluate these concepts relative to the specifications, targets, and current device.

j. Include one or more detailed sketches and a description of each of your recommended improvements.

10. Team Assessment (15 Points)

a. A description and analysis of how your team worked together to complete the project and what you learned about teamwork (how did the team overcome conflict/issues to successfully complete the project? How were you able to work harmoniously together?).

b. Include as much reference material as possible (team contract, meeting minutes, team health **templates**).

c. Every team member should contribute to this assessment.

11. References (15 Points)

a. Any information, data, figures, etc. included throughout the report that is not of your own creation must be cited using the IEEE format.

b. Citations must be numbered throughout the text, with the citation information listed (by corresponding number) in the "References" section.

12. "Wow" Factor (15 Points)

a. Obvious and deliberate effort to produce the a professional, organized, and accurate project report.

b. See "The Grading" section of this document for details.

<u>List of Available Templates</u> (see "Pages" in Canvas)

1. Meeting Minutes ***Required***
2. Team Health ***Required***
3. Team Contract ***Required***
4. Project Plan ***Required***
5. Customer Requirements ***Required***
6. Reverse Engineering ***Required***
7. Bill of Materials (BOM) ***Required***
8. Quality Function Deployment (QFD) ***Required***
9. Design for Assembly (DFA) *Could help in finding a device improvement*
10. Morphology *Could help in finding a device improvement*

The Grading

95% of the points are awarded based on a review of the completeness, accuracy, and quality of the report sections identified under "The Deliverable". The relative importance of each section can be determined by the point values noted above. The report should be typed, formatted, and written in a professional manner – something that you would be proud to share with a prospective employer. See Canvas for examples of quality reports, but note that these reports are from previous semesters and may be organized differently or lack some of the current requirements.

The remaining 5% of the points are based on the "wow" factor of your report. Examples from previous reports include:

- Reports that looked significantly more professional or clear than the others.
- Superior visual presentation of the theory of operation of the device.
- Exceptionally good technical research and analysis.
- An improvement that was particularly clever and well-supported by analysis.
- Excellent detail about how your team functioned and how team-related issues were addressed.
- Additional information that is relevant, but not requested.
- Tasteful, clever, and relevant humor.

To summarize, completeness, accuracy, professionalism, and initiative are key ingredients of a good report. Each group is encouraged to first strive for **completeness** by confirming all requirements of the report have been included. Then, check that everything is **accurate** (e.g., review data, dimensions, etc.). Next, present the work in the most organized and **professional** manner possible. Finally, you are encouraged to include *relevant* additional materials that demonstrate your group went beyond the base requirements to complete this project.