**Rice University Collaborative Capstone Design** 

**Documentation Instructions**

*Objectives*

**Why you do it**

Engineered products are defined by their specifications. A product’s specifications provide a quantitative metric of the performance of a product as measured by well-defined, objective testing methods. It should always be possible for an impartial observer to determine whether a product is meeting its specs. Products that fall out of spec may require warranty repairs, costing the manufacturer significant expenses.

In the real world, specification documents can contain many hundreds or thousands of items. Those are the just the “customer-facing” specs. There may be many more internal specs dealing with subsystems of the overall product. It is obviously impractical for a capstone project to utilize so many specs. However, designing to specs is one of the key activities of practicing engineers. Accordingly, in this course at the end of the year you will include your testing of your project’s performance vs. specs in the Final Report (Cycles 4 and 5). There will also be a “Final Design Review” oral presentation at the end of the year.

Your team also will commit to achieving a number of intermediate technical milestones at various points in the year. In this course, these are called “Objectives.” In this course the commitment to intermediate technical objectives is captured in the “Objectives” sections of the Product Development Worksheet.

**How objectives work in this course**

In this course the *majority* of team points come from achieving objectives as listed in the Objectives sections of the Product Development Worksheet. Performance against Objectives are graded at Cycles 2, 3, and 5. At a specified due date earlier in the semester, the team completes and submits the appropriate table. The team provides a list of concrete objectives that they commit to achieve, along with a number of team grade points that achievement of each objective is worth. In each Cycle the point values for the objectives should sum to the specified amount. In Cycle 2, the total should be 1500; in Cycle 3, 2000. In Cycle 4 / 5 sum of points for achievement of Objectives plus achievement of Specs will be 2000 points. There is a maximum number of points you can assign to any one Objective or Spec, as shown on the relevant tables in the Product Development Worksheet.

The high number of points assigned to achievement of Objectives and Specs is to ensure that teams are focused on achieving technical progress throughout the year. The Objectives and Specs are determined by the team itself (with approval from faculty) so the team should be working towards goals that they have determined to be most important. In each Cycle the team will submit a draft of their Objective sheets. Faculty will provide feedback, and the team and faculty will reach agreement on the content of the Objectives.

Each Objective Sheet reflects a different phase of the project and is submitted at a different point in the school year. Roughly speaking, each team should have, by the end of Fall semester, a “proof of concept” -- some core element of their project that works at some level. Then, by Spring Break, teams should have their subsystems working separately and initially integrated into a system (though not fully tested). Then, by the Design Showcase the team should have a well-revised and well-tested system that meets most of its Functional Specifications and that, ideally, can be demonstrated to an audience. Then by the end of the semester (Cycle 4/5) the system should be complete and meeting all of its specs. There are multiple opportunities to revise objectives and specs along the way, although the team has to justify if they de-commit from major objectives. There is no guarantee that customers or faculty will accept if a team de-commits from a spec.

The process for Objective evaluation is essentially the same as for FOSS, although in this case the faculty will hold teams accountable for achieving their objectives rather than just making an effort. The team will present the results in a Design Review presentation. See the Oral Presentations document for more instructions about how to make the presentation.

1. Cycle 2 Fall Design Review -- You will submit these objectives in the middle of Cycle 2. Submit a hardcopy version in the OEDK on the due date. (You can submit finala softcopy instead to your course faculty member(s) if they prefer.) Course faculty will review the sheets and return them promptly for revisions, which will be due about a week later. The spec sheets will then be graded according to the rubric below, and will be worth a relatively small number of points for Design Cycle 2.   
     
   Then at the end of Design Cycle 2, in your team’s Fall Design Review presentation, you will demonstrate your project’s performance as compared to the specs you listed previously on the Cycle 2 Objectives table. Performance vs. stated objectives will be worth a large number of points. Performance will determine how many team points you are awarded in the Design Execution (Cycle 2) section of the Capstone Documents Grading spreadsheet.
2. Cycle 3 Functional Prototype Review -- At the end of Cycle 2 you will submit the Objectives for Cycle 3. Your course faculty will grade the document according to the rubric below. A revision of the document will be due at the beginning of Spring semester. As with Cycle 2, the Objective Sheet itself will be worth a relatively small number of points, but the Functional Prototype Review at the end of Cycle 3 in Spring Semester will be worth a large number of points. Performance will determine how many team points you are awarded in the Design Execution (Cycle 3) section of the Capstone Documents Grading spreadsheet.
3. Cycle 5 Final Design Review. -- At the end of Cycle 3 you will submit the Objectives table for Cycle 5 and a final revision of the Specifications with point values assigned for achievement of each Spec and Objective. (Your course faculty may also give you an opportunity to revise your Specifications in addition to assigning final point values.) Your course faculty will grade the document according to the rubric below. As with Cycles 2 and 3, the Objective Sheet itself will be worth a relatively small number of points, but performance vs. Objectives and Specs, as determined at the Final Design Review at the end of Spring Semester will be worth a large number of points. Performance will determine how many team points you are awarded in the (Cycle 5) Design Execution section of the Capstone Documents Grading spreadsheet.

**Allocating point values for meeting Objectives**

Each Objective / Spec Sheet also allows the team to allocate their points among the various specs & milestones. The majority of points should be allocated to the most important objectives. Less critical specs, nice-to-have features, etc. should be allocated fewer points. ***At least 10% of the points in Cycles 2 and 3 should be allocated to “stretch goals”*** –those that are high-risk (in the opinion of the team and the mentor or advisor.) The team and mentor/ customer should discuss and agree on the allocation of points. The course professors have the option of changing the point allocation. For instance, suppose a team was building a web-enabled bread-slicing machine, and that in Design Cycle 2 there were 1500 points to allocate, with no single item allowed to be over 300 points. The team might allocate 300 points to demonstrating functionality on a hand-driven bread slicer, 300 points to a basic user interface on a standalone PC that has a start & stop button, 300 points to the measurement of the cutting properties of various knives, 300 points for developing a basic mechanism for moving knives around (but without knives), 150 points for demonstrating web connection of the user interface, and 150 points to a mechanism that allows multiple knives to be used simultaneously (the latter being a stretch goal.)

*What if the team discovers they won’t be able to meet the objectives committed to in the previous design cycle?*

There is always some risk when committing to achieving definite objectives by a particular date. In this course the commitment happens about 3-8 weeks in advance of the test. A lot can go wrong in the interim: unforeseen technical roadblocks, unavailability of key parts, teammates who disappear for a week to work on other classes, or -- most commonly -- just an underestimate of the time required. That is the nature of engineering. In the real world, it is sometimes possible to get approval from the customer on reduced specs, slipping of a schedule or re-negotiation of costs as it becomes clearer that the original specs/ schedule/ cost were too optimistic. In this capstone course, the team is allowed to change the Objectives or Spec Sheets, including point allocations, assuming the team can get approval from the customer/ mentors and the professor. The profs do understand that adversity outside of the team’s control does sometimes occur, and may take that into account when deciding whether to allow teams to de-commit from agreed-upon specs. In the real world, your customer might not be so understanding.

**Writing good objectives**

A spec or milestone or objective needs to have an unambiguous way to determine if it is met – an associated test. Sometimes this is easy because it is purely quantitative and obvious how to measure it: “Output power > 100 W”, ”Volume < 1 liter” etc. Sometimes a more “squishy” spec has to be included, such as “intuitive graphical user interface.” In this case one should try to make the test semi-quantitative, as in “At least 80% of all users rate intuitiveness 4 or 5 on a scale of 1-5.”

In this course you are allowed to pre-designate “partial credit” for partial achievement of specs. Sometimes this is done in the real world as well – the design team may have some incentive bonus based on performance of the product. Consider the following example: The objective is a 12-lead wireless electrocardiogram system with battery life of 1 week, worth 500 team points. The team, not sure if they could hit the aggressive battery spec, could stipulate 350 team points for achievement of 8 hours of battery life and the full 500 points if the full spec is met. The different levels of objectives can be addressed by separate line items in the spreadsheet or simply by noting the point assignment in the appropriate cell in the spreadsheet.

**How to fill out the Objective Sheet**

The Objective Sheet is pretty self explanatory. There are 4 columns: Associated Specification, Description of the Objective, Potential Points, and Assigned Points.

In the first column, for each Objective, list the Specifications (as tabulated in the Functional Specifications section of the Product Development Worksheet) that are associated with each Objective. There could be more than one Specification that drives an Objective but there needs to be at least one -- if a major milestone is not driven by a Spec then the team should question why they are doing it.

Points Possible: This is the number of points your team can achieve if the Objective is completed. The total Points Possible should match the total provided at the bottom of the table (1500 for Cycle 2, 2000 for Cycle 3, etc.)

Points Awarded: to be filled out at the various Review presentations, reflecting whether or how well the particular spec was met. The total of Points Awarded will get entered by the course faculty into the documentation grading sheet in the Design Execution line item.

**Review Presentations**

For details on how to prepare for the Review presentations associated with the Objective Sheets, check out the separate document on presentation instructions and associated rubrics.

[Rubric for Objective Sheets](https://docs.google.com/a/rice.edu/document/d/1ppZFTxPv4mSABp7BVgyWtTLL90pBW9cA9KkOJRZ8WO4/edit?usp=sharing)

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