Chapter 2 – Project Selection and Needs Identification

1. **In your own words, describe the differences between creative, variant, and routine designs. [R]**

   Creative designs are typically new and innovative design ideas – those that did not exist before. Variant designs are variations of existing designs, with the intent of improving some aspect of the existing system. Routine designs are concerned with fairly well-known artifacts for which there is a well-developed design knowledge base.

2. **List three guidelines that should be employed when selecting projects in practice. [R]**

   (1) The project must be tied to the mission and vision of the organization; (2) The project must have payback; (3) The project should be selected with criterion; (4) The project objectives should be SMART (Specific, Measurable, Assignable, Realistic, and Time-Related).

3. **Assume a customer comes to you with the following request—*Design a mechanical arm to pick apples from a tree*. What are the assumptions in this statement? Rewrite the request to eliminate the assumptions. (This problem was originally posed by Edward DeBono [Deb70]). [A]**

   This statement contains a solution based on the assumption that a mechanical arm (by means of picking) is the best method for removing apples off of a tree. Therefore, the design space is immediately and needlessly limited. Also, we are unsure if there is a problem with current methods of removing apples. Here is a better statement:

   "Design a device that can improve the current method of removing apples from a tree."

   This statement is rightly ambiguous in the sense of not specifying how, or from what, to build this device. This is the type of question and approach that should be sought for establishing a needs statement.

   > ***Note:*** *Including the word "mechanical" may be permissible, as it clearly defines a type of device, but does not specify further details or characteristics. This situation poses a fine line between problem and solution.*

4. **Assume a customer comes to you with the following request—*Design an RS-232 networked personal computer measurement system to transmit voltage measurements from a remote location to a central server.* What are the assumptions this statement? Develop a list of questions that you might ask the customer to further clarify the problem statement. [A]**

   This statement, much like the one confronted in problem 3, is filled with numerous assumptions and solutions. The statement proves troublesome because both the problem (transmit voltages measurements from remote location to central server) and solution (RS-232 networked personal computer) are given to together. Furthermore, you – as the Engineer – are unsure if the prescribed solutions are the best decisions for this particular problem. In order to dissect the statement and get to the actual problem, a list of questions must be asked.

   Sample Questions

- What is the purpose of this transmission system?
- Why are voltage measurements currently being sent? What do they represent?
- How are the measurements currently being made?
- What are the problems with the current system?
- What do you like about the current system?
- What type of atmosphere will this device most likely be engaged in?
- Do you plan to implement multiple measurement systems?
- Why use RS-232?
- What is the purpose of the central server?
- What are the voltage measurements of?

Note: *The questions given here are variations on those presented in the book to ask the client when starting into a new project. The objective in asking this question is to get practice in asking these questions. Students are often hesitant to ask questions, particularly if they are working with an industrial sponsor. It help to give them practice in do this before they meet with their customer.*

5. Describe what is meant by a marketing requirement. [R]

A marketing requirement is a statement that describes a need in the language of the end-user or customer. It should describe what the system should do, not necessarily how it will be accomplished.

6. What is the purpose of an objective tree and how is it developed? [R/A]

The objective tree is a graphical representation of the customer/end-user needs in a hierarchical layout. It is developed by determining the customer needs (through interviews, observations, etc.) and then translating the results of that into a set of specified needs. The needs are categorized into a hierarchy which is represented in the objective tree. The categorization is based upon functionality, not importance.

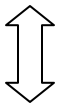
7. The needs for a garage door opener have been determined to be: safety, speed, security, reliability, and noise. Create a pairwise comparison matrix to determine the scores and rankings of the five needs. Apply your own judgment in ranking the needs. [A]

DEVICE: Garage Door Opener
NEEDS: Safety, Speed, Security, Reliability, and Noise

	Safety	**Speed**	**Security**	**Reliability**	**Noise**	**TOTAL**
Safety	X	1	1	0.5	1	**3.5**
Speed	0	X	1	0	0.5	**1.5**
Security	0	0	X	0.5	1	**1.5**
Reliability	0.5	1	0.5	X	1	**3**
Noise	0	0.5	0	0	X	**0.5**

Paired Comparison Matrix

Rankings

Most Important: Safety

Reliability
Security
Speed
Least Important: Noise

Note: There is no single solution, and the results are somewhat subjective. However, safety should always be of the highest concern in such an application. The objective of this problem is to demonstrate that students can create a matrix, make it consistent, and compute the scores.

8. Consider the design of an everyday consumer device such as computer printer, digital camera, electric screwdriver, or electric toothbrush. Determine the customer needs for the device selected. The deliverables should be: 1) marketing requirements, 2) an objective tree, and 3) a ranking (pairwise comparison) of the customer needs. [A]

Note: *The objective of this question is to give the individual (or preferable a small-team) practice in identifying the needs. Fairly simple and common products should be used as a first step. This can be a very good exercise for the class. Each team could select its own product and then some teams can present the results to the class. Or several or all teams could work on the same project, with a reporting session, where a team presents their findings and the others critique them.*

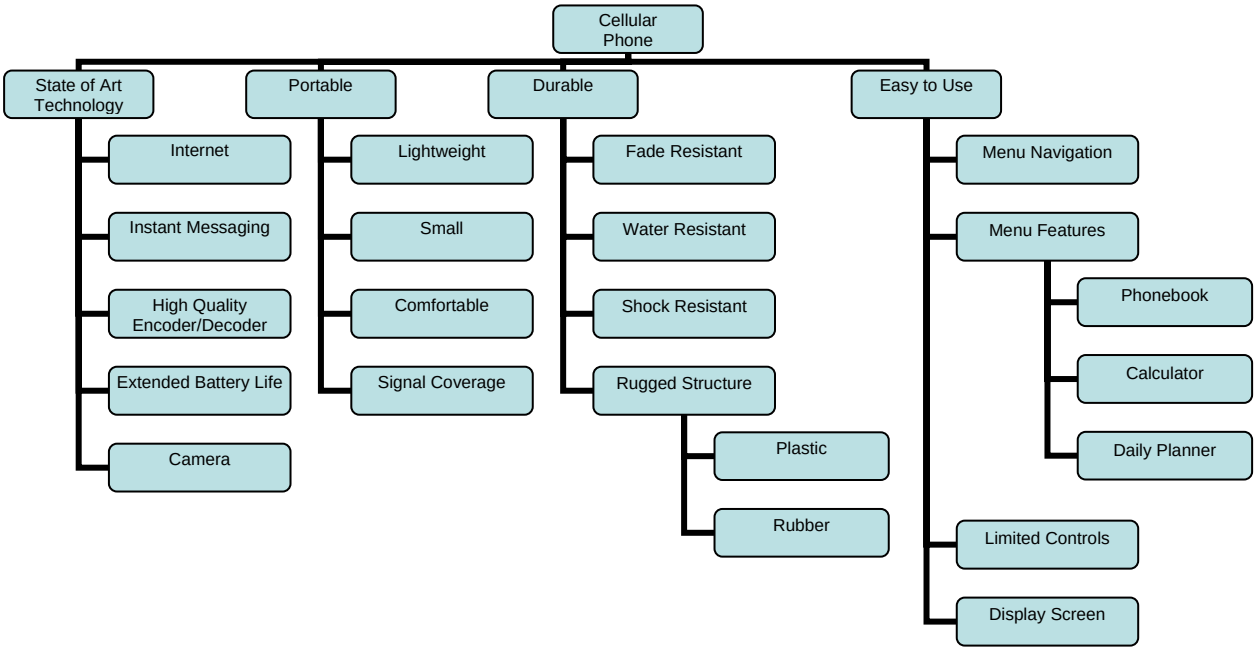
Consumer Device Selected: **Cellular Phone**

Need: With today's high-paced world, immediate contacts are essential. Therefore, excellent cell phone design, implementation, and construction are a must.

1. Marketing Requirements

- The system will be lightweight.
- The system will withstand abusive treatment (dropping, running over, etc.)
- The system will be comfortable and ergonomic.
- The system will have high-quality audio encoding and decoding.
- The system will not have to be frequently charged.
- The system will have good signal pickup.
- The system will survive from weathering (sun, rain, etc.)
- The system will be easy-to-use.
- The system will be able to connect to and browse the internet
- The system will contain as few buttons as possible

2. Objective Tree



3. Ranking of Customer Needs

	Technology	Portable	Durable	Easy-to-Use	TOTAL
Technology	X	0.5	0.5	0.5	**1.5**
Portable	0.5	X	0.5	0.5	**1.5**
Durable	0.5	0.5	X	0	**1**
Easy-to-Use	0.5	0.5	1	X	**2**

Cell Phone Attributes

	Internet	IM	Audio	Battery	Camera	TOTAL
Internet	X	0.5	0	0	1	**1.5**
IM	0.5	X	0	0	0	**0.5**
Audio	1	1	X	0.5	1	**3.5**
Battery	1	1	0.5	X	1	**3.5**
Camera	0	1	0	0	X	**1**

State of the Art Technology

	Lightweight	Coverage	Small	Comfortable	TOTAL
Lightweight	X	0	0.5	0.5	**1**
Coverage	1	X	1	1	**3**
Small	0.5	0	X	0	**0.5**
Comfortable	0.5	0	1	X	**1.5**

Portable

	Fade Res.	Water Res.	Shock Res.	Rugged	TOTAL
Fade Res.	X	0	0	0.5	**0.5**
Water Res.	1	X	0.5	1	**2.5**
Shock Res.	1	0.5	X	0.5	**2**
Rugged	0.5	0	0.5	X	**1**

Durable

	Navigation	Features	Lim. Ctrls	Display	TOTAL
Navigation	X	0.5	0.5	0	**1**
Features	0.5	X	0.5	0	**1**
Lim. Ctrls	0.5	0.5	X	0	**1**
Display	1	1	1	X	**3**

Easy to Use

	Phonebook	Calculator	Planner	TOTAL
Phonebook	X	1	1	**2**
Calculator	0	X	0	**0**
Planner	0	1	X	**1**

Menu Features

	Plastic	Rubber	TOTAL
Plastic	X	0.5	**0.5**
Rubber	0.5	X	**0.5**

Rugged Structure

Rankings

Most Important: Extended Battery Life and Audio Encoding/Decoding (**3.5**)
Signal Coverage and Display Screen (**3**)
Water Resistant (**2.5**)
Easy to Use, Shock Resistant, and Phone Book Feature (**2**)
State of the Art Technology, Internet, Portable, and Comfortable (**1.5**)
Durable, Camera, Lightweight, Rugged, Menu Navigation, Menu Features, Limited Controls, and Daily Planner (**1**)
Instant Messaging, Small, Fade Resistant, Plastic, and Rubber (**0.5**)
Least Important: Calculator (**0**)

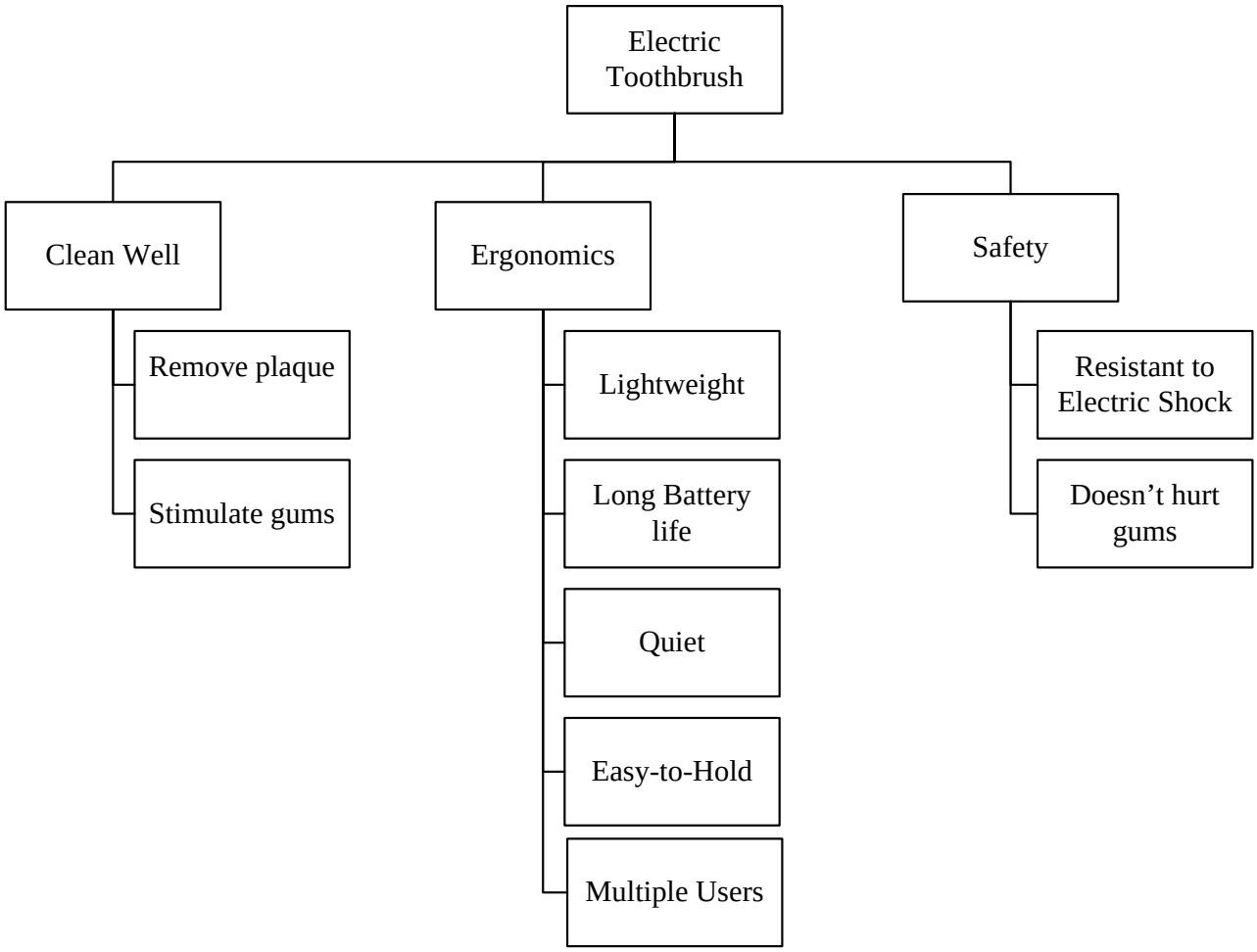
HERE IS A SECOND EXAMPLE FOR AN ELECTRIC TOOTHBRUSH

Toothbrush Example

Marketing Specifications

- Should be lightweight
- Clean teeth well.
- Have a long battery life.
- Not shock the user (electric).
- Easy to hold
- Quiet.
- Easy to clean.
- Be lightweight.
- Allow multiple users.

Objective Tree



Rankings

Highest Level

	Cleaning Ability	**Ergonomic**	**Safety**	**Score**
Cleaning Ability	-	1	1	2
Ergonomic	0	-	1	1
Safety	0	0	-	0

A = 2, B = 1, C = 0

Rationale: Cleaning would be the main selling point, but ergonomic is important too – if it is clunky, user would not want to use it. Could actually make the argument that ergonomic is more important than cleaning ability, and that would depend upon the target market (higher or lower cost). Safety is important, but electric toothbrushes are pretty safe devices that have been around for a long time, so may not be the top priority from the user's point of view.

Second-Level: Ergonomics

	. Lightweight	Battery Life	Quiet	Easy-to-hold	Multiple Users	Score
Lightweight	-	0	0	0	0	0
Battery Life	1	-	1	0	0	2
Quiet	1	0	-	0	1	2
Easy-to-hold	1	1	1	-	0	3
Multiple Users	1	1	0	1	-	3

9. **Project Application. Select criteria to be applied for selecting a project concept as shown in Table 2.1 in Section 2.2. Candidate criteria are cost, time, and match with team member skills, to name a few. Then brainstorm to generate project concepts. Rank the top three to five concepts against the criteria selected as presented in Section 2.2. [P]**

   Note: *If the teams are being allowed to select the project, this is a good exercise to get them to focus on criteria for project selection. Conflict often develops between team members over which project to pursue, and this provides an opportunity to examine the merits of different projects. Criteria to consider are: cost, time to completion, team member skills, probability of success, interest in the project, etc.*

10. **Project Application. Determine the needs for the project selected. The result should be list of marketing requirements, an objective tree, and a ranking of the needs. [P]**

    Note: *The objective here is the same as question 8, with difference being that it is applied to the capstone design project. A difficulty here could be that the customer may not be as easily identifiable, an example being a design competition. If the team is developing a new and creative product idea, they should be able to do this. If they are working on an industry sponsored project, they should also be able to do this. In the case of design competition or another type does not lend itself as well, the team still should be able to develop an adequate objective tree based on the project rules and their knowledge of the subject. We have had teams be very creative in finding ways to identify the customer needs from conducting web-based surveys on bulletin boards and to conduct focus groups with other students on campus.*

11. **Project Application. Develop an Extended Problem Statement for your project concept as outlined in Section 2.6. Apply the processes presented in the chapter as appropriate for the project. [P]**

    Note: *We typically have the teams complete the simple Problem Statement similar to those in Examples 2.1-2.3 in the text. Along with this they submit a justification for the team they have selected (Team Proposal) that identifies who the members are and what objectives/skills they bring to the team.*

    Once the basic Problem Statement and Team Proposal are completed and reviewed by the instructor, it is then followed by a more detailed submission of the Extended Problem

Statement that is presented in the Project Application Section. This integrates all of the material from Chapter 2. In term of research, the goal here is to provoke the team to conduct research up-front and show they understand what is going on. In our experience, this is often overlooked, and teams regret it later. In our course, we typically get a 3-6 page report summarizing their findings. Our goal is to determine their level of understanding based upon that. All of this makes up part of the final design report submitted at the end of the project.

Additional In-Class Exercise

The following exercise is one we use early on in the class to generate project ideas. The class is usually capable of generating at least one idea per minute, and we often get 40-50 ideas in a session.

As a class, the objectives are as follows:

- Generate a minimum of 40 project ideas.
- Every single student in the class must offer at least on idea.
- If the two above criteria are met, then everyone in class gets a 10 point (100%) quiz grade. Otherwise, no grade recorded.

Rules of Brainstorming

1. No criticism or judgment of idea
2. Wild ideas are encouraged.
3. Quantity is stressed over quality.
4. Build upon and modify the ideas of others.
5. All ideas are recorded.

Note: *Another option is to present a particular problem or application area and have the teams students generate ideas based upon them.*

Background and Technology Survey Instructions

You should consult with your supervising faculty member when developing this section of the report. Each project is unique.

The objectives of this section are to:

- Provide your audience (faculty, project sponsors, other students, etc) with sufficient background so that they understand the problem the team plans to solve.
- Demonstrate that the team has a sufficient understanding of the problem to proceed to the next stage of development.
- Demonstrate that the team has conducted research and understands the technology relevant to this project – namely, related solutions to the problem and their limitations. Depending on the project, you should also conduct searches on the US patent database for similar technologies.
- To describe what is new/unique in the proposed design.
- To provide additional supporting information that for the Need and Objective statements.

Pointers:

- If it is an industry sponsored project, you will need to provide a clear overview of the problem and any related processes. You should also indicate why it is important to the organization – what benefit it will provide.
- You may provide more detail on the need for the project. For example, if this has market potential, indicate what the size of the market is. If you are preventing injuries – how many injuries are there per year? Supporting statistics are always great to demonstrate the need.
- If there are similar systems out there, describe limitations of current designs or technology. Benchmarking or strength/weaknesses analyses of existing technologies are powerful.
- Describe any basic theory to be described regarding the technology. For example, say you are designing a flywheel energy storage system – you should describe the basics of how flywheel energy systems work – what are the major systems, etc.
- Pictures always help - be sure to provide a description of diagrams.

On the writing itself:

- This is expected to be well-written prose.
- You **must** provide a reference section. Reference all sources used – do not plagiarize. If you use a figure that is not yours, you must provide a clear reference as to where it came from – if not it is plagiarism (in which case you get a zero and reported for academic integrity hearings).
- Follow the same format for references as used in the class textbook. Make sure that you reference web pages properly.
- All figures and tables must be labeled. Follow the same format used in the book for labeling and referring to figures and tables.

- This should be concise 3-4 pages in length. You cannot exceed 4 pages of 11 point with 1” margins.

Format for the report

Use 12 point Times New Roman bold for the headings of the section. 11 pt for text, 1.5 spacing between paragraphs.

Title

Team Members

1. Need

Text goes here – it should be 11 pt, Times- New Roman single spaced. Use 1.5 spacing between the paragraphs.

2. Objective

Text goes here – it should be 11 pt, Times- New Roman single spaced. Use 1.5 spacing between the paragraphs.

3. Background and Technology Survey

Text goes here – it should be 11 pt, Times- New Roman single spaced. Use 1.5 spacing between the paragraphs.

4. Marketing Requirements and Objective Tree

List the marketing requirements (numbered), Objective tree, and a summary of the ranked needs.

References

Appendix – Ranking of Needs

List the marketing requirements (numbered), Objective tree, and a summary of the ranked needs.