DESIGN OF SOUND OR LIGHT ACTIVATED HANDLE-FREE DOOR OPENING MECHANISM OF FULLY INTEGRATED DISHWASHER

By

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ABSTRACT

AN APPROXIMATE MODEL FOR KANBAN CONTROLLED ASSEMBLY SYSTEMS

Engin Topan

August 2005, 160 Pages

In this study, an approximation is proposed to evaluate the steady-state performance of kanban controlled assembly systems. The approximation is developed for the systems with two components making up an assembly. Then, it is extended to systems with more than two components. A continuous-time Markov model is aggregated keeping the model exact, and this aggregate model is approximated replacing some state-dependent transition rates with constant rates. Decomposition of the approximate aggregate model into submodels guarantees product-form steady-state distribution for each subsystem. Finally, submodels are combined in such a way that the size of the problem becomes independent of the number of kanbans. This brings about the computational advantage in solving the combined model using numerical matrix-geometric solution algorithms. Based on the numerical comparisons the approximation is observed to be good in terms of accuracy with respect to computational burden and has the potential to be a building block for the analysis of systems that are more complex but closer to real-life applications.

Keywords: Assembly Systems, Approximation, Performance Evaluation, Matrix Geometric Solution, Kanban Control, Steady-State Behavior.

STATEMENT OF NON-PLAGIARISM

We hereby declare that all information in this report has been obtained and presented in accordance with academic rules and ethical conduct. We also declare that, as required by these rules and conduct, we have fully cited and referenced all materials and results that are not original to this work.

Date:

Group Member's Name and Surname	Signatures
Çağrı CİNDİOĞLU	_____
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INTRODUCTION (MECE 407 REPORT WRITING GUIDELINES)

You should use this document as the template for your report.

I.1. Report Style

The reports must be written in English and free of spelling, typing or grammatical errors. The reports are graded considering style, format, organization of the report as well as the technical information provided.

The report can be prepared using any standard text editor. The reports should be written using A4 size paper with 3 cm left, 2.5 cm top, 2.5 cm bottom, and 2.5 cm right side margins. For the body of the report, Times New Roman should be used with a font size of 12 and 1.5 line spacing. Each chapter should start on a new page. A 14 font size-Times New Roman bold typeface is used for one of the chapter headings, other chapter headings should have the same style. Each figure or table presented in the report should be referred in the text, preferably just before the figure or the table. In addition, each figure and table should have a proper descriptive caption (examples are Table 1 and Figure 1). If a figure or a table is not of ultimate importance, or it is inconvenient to present the figure or table inside the text (for instance due to its physical size), it may be considered to place the entity in the appendix. If appendices are used, they should be referred as well in the text.

Table 1. Some coarse metric threads

Size - Nominal Diameter (mm)	Pitch (mm)	Clearance Drill (mm)	Tap Drill (mm)
M 1.60	0.35	1.80	1.25
M 2.00	0.40	2.40	1.60
M 2.50	0.45	2.90	2.00

Figure 1. Mechatronics Engineering Department logo

I.2.   Referencing

In the report, present the references as a separate list at the end of the main body. Use citation style throughout the report. For instance:

[1] Multiphysics Modeling and Simulation Software COMSOL, Last access date: 20 May 2012.

[2]http://mece.cankaya.edu.tr/Underg_Courses.htm:Mechatronics Engineering Department offers 4-year undergraduate program.

I.3.   Content of the Reports

Final Report should contain the following sections and chapters:

Title Page: It should include, course and project name, your name and address with telephone and e-mail, supervisor's name, date, university and department, city, country (1 page). The title must be one-half (1.5) line spacing, all in capital letters, and should begin at 9 cm from the top of the page. The title must not contain chemical or mathematical formulas, symbols, superscripts, subscripts, Greek letters, or other non-standard abbreviations and characters; words must be substituted for all these. The format of the title page, including spacing and capitalization, must be exactly as in the sample title page shown in Appendix A.

Abstract: This should be ½ to 1 page executive summary presenting a complete and concise description of the design project, including project objectives, efforts and accomplishments. The purpose of the executive summary is to provide key information up-front, such that while reading the report, a reader has expectations that are fulfilled on a continuous basis. Key to a good Summary is the first sentence, which must contain the most essential information that you wish to convey.

a)   The summary is to be written as if the reader is totally uninformed about your project and is not necessarily going to read the report itself.

b)   It must include a short description of the project, the process and the results.

c)   The Executive Summary is to be one page or less with one figure maximum.

Summary must not exceed 250 words, must not include diagrams, and should not include mathematical formulas unless essential. A sample abstract page is provided in the page i.

Keywords: Keywords (and Phrases, if necessary) of your project will be given on the last line of your abstract in an alphabetical order.

Özet: Abstract in Turkish.

Anahtar Kelimeler: Keywords in Turkish.

Acknowledgements: (Optional) Acknowledgment should include "thanks" to supervisor(s)/co-supervisor(s) (at the first place), people reviewing the report, persons who contributed and helped preparing the report in terms of providing support such as providing data, information, encouragement, etc. The heading Acknowledgement appears centered between the text margins 5 cm from the top of the page. The text begins at least three line spaces below the heading.

Statement of Non-plagiarism Page: This page includes the statement signed by the group members about plagiarism (1 page). A sample plagiarism page is provided in the page ii.

Table of Contents: The table of contents must list the title of each chapter and its parts and sections, references, and appendices. The wording used for all entries in the table of contents must match exactly with what is used in the text. Each entry must have leading dots which connect it to its corresponding page number.

The heading "Table of Contents" appears without punctuation centered between the text margins 5 cm from the top of the page. The listing of actual contents begins at the left margin at least three line spaces below the heading. .

List of Tables: All tables given in this section should be cited within the main text.A list of tables should be included for the convenience of the reader if the main body contains more than table (those in appendices are excluded). It will immediately follow the table of contents on a new page.

The heading "List of Tables" appears without punctuation centered between the text margins 5 cm from the top of the page. The listing of actual contents begins at the left margin at least three line spaces below the heading.

Each entry should have the same number and the same caption or title used for a table in the text, although a long caption may be abbreviated to the extent of using only the first full sentence. As in the table of contents, each entry must have leading dots which connect it to its page number.

List of Figures: All figures given in this section should be cited within the main text.

These lists must appear on separate pages and are governed by the same rules as the list of tables.

List of Equations: All equations given in this section should be cited within the main text.

List of Appendices: Engineering drawings and all other necessary appendices should be included.

The list must appear on separate page and is governed by the same rules as the list of tables.

Nomenclature

Introduction: Introduction to the problem. Statement of the design problem in detail. The reasons for the need of this design. Overview of design specification and performance targets. Description of the design methodology and steps that were followed. Outline of the interim report. Give a clear and concise definition of the problem and the intended objectives. Outline the design constraints and cost implications.

a)   Include appropriate background on the project for the reader to be able to put the information provided in context.

b)   The final project objectives must also be presented in the form of a set of technical specifications.

Introduction is the first chapter of the report, which introduces the work, provides the motivation and context and outlines the significance of this work. Therefore, Chapter 1 should be entitled as INTRODUCTION. The heading should be centered between the text

margins 5 cm from the top of the page; the title goes two line spaces below. The text begins at least three line spaces below.

Main text: The main body of the report is divided into multiple chapters to help the reader in understanding the subject matter. Although the detailed organization of the text varies among academic disciplines, the formatting of the text must be consistent throughout. All

headings and subheadings should be presented in the same way in each chapter, in terms of capitalization, placement on the page and kind of type used.

Only chapters should begin with a new page. Within a chapter, the presentation of subsections must be continuous: partially filled pages of text are acceptable only on non-textual pages, such as those presenting tables and illustrations.

The headings of chapters are all in capitals and centered between the text margins 5 cm from the top of the page; the title goes two line spaces below. The text begins at least three line spaces below.

In many cases, the main body of the report will include certain materials other than ordinary text, such as illustrations, formulas, quotations, footnotes, and endnotes. In such cases, the following guidelines should be observed.

Notes for Illustrative Material

Illustrations include drawings, charts, figures, tables, diagrams, plates and photographs. These may be inserted wherever the author feels appropriate, but as a general rule, they should appear as near as possible to the part of the text relating to them. An illustration should be separated from the text or another illustration by at least a single line space.

Illustrations of one-half page or less in length may appear on the same page with the text, separated from the text above and below by triple line spacing illustrations longer than one- half page are better placed on a separate sheet.

Illustrations that are too large to be placed sideways between the left- and right-hand margins should be rotated counterclockwise 90 degrees so that the top of the illustration runs parallel to the left-hand margin of the page. The caption or legend for such an illustration must also be rotated. When illustrations are presented in this manner, the usual margin requirements remain in effect, and page numbers should appear in their normal place.

Illustrations of any kind must be numbered consecutively. This includes appendices, if you have them. You may follow a straight sequence (1, 2, 3, etc.) or use a decimal approach (1.1, 1.2, 1.3, etc. or A.1, A.2, A.3, etc.) where the first digit is the chapter or appendix number, and the digit after the decimal point is the illustration number.

Tables may run longer than one page. In such cases all subsequent pages of the table must include at least the table number and the notation that it is continued, e.g., "Table 1 (cont'd.)" or "Table 1(continued).". This is only valid for tables; figures cannot be separated in this manner.

All headings and captions of illustrations must be prepared in the same typeface and point size used for the text. The words illustrations' type and their numbers should be all in bold, e.g., "Table 1.2 Two-factor ANOVA Results", "Figure A.1 Organization Chart".

Table numbers and captions are placed single space above the top line of the illustration, figure numbers and captions are placed single space below the last line of the illustration. If an illustration other than table is borrowed from a source, then the source should be

referred in parenthesis below the illustration's caption. If a table is borrowed from a source, then the source should be referred in parenthesis below the table.

Authors may treat oversized materials in one of the following two ways:

- An illustration may be photo-reduced, but its page number and caption must be the same size and typeface as in the rest of the illustrations.

- An illustration may be folded and inserted in either of the following ways:

. Fold the illustration and insert it in a white or manila envelope no larger than 16.5 by 24 cm, which may be mounted on paper of the proper weight for inclusion in the report. Each page enclosed in the envelope must be included in the pagination of the report; the page on which the envelope is mounted should have a single page number or inclusive page numbers, as needed.

   . Fold the illustration and mount it on 21 by 29.7 cm sheet (A-4).

Notes for Formulae

Mathematical and chemical formulae, equations and expressions should be printed. Number the equations needed to be referred consecutively from the text. You will not number the equations which are not to be referred consecutively within the text; this means that you will not number the equations referred for once only. Be careful that all the notation you use is defined and beware of using the same mnemonic for two different variables.

Provide the reference for all equations taken from a source, including a textbook or a handout. Embed the reference in the text; do not put the reference on the same line as the equation:

"Bernoulli's equation for incompressible flow is given by Equation 15.2 of Beckwith et al. (1982) as:

$$\frac{P_1 - P_2}{\rho} = \frac{V_2^2 - V_1^2}{2g_c} = \frac{(Z_2 - Z_1)g}{g_c} \qquad (1)$$

Define all symbols immediately after they are first used

Mechanical output power is calculated from the formula

$$P = \tau \varpi \qquad (2)$$

where

P is the power (typically horsepower or watts),

τ is the torque (typically ft-lbf or N-m), and,

ϖ is the angular velocity in RPM (revolutions per minute),

Number each equation sequentially in parentheses as shown. The equation can then be referenced by number, e.g., "Equation (2) was used to compute motor power output.". Center equations, and number them along the right margin, e.g., see examples above.

Not acceptable: $Y\max = 3 * Pa\text{^}4/16 * Et * 3 * (1 - v\text{^}2)$ \qquad (4)

Not acceptable: $Y_{max} = 3Pa^4/16Et^3(1 - v^2)$ \qquad (5)

$3Pa^4$

Refer to a numbered equation with a capital "E", e.g., "... Equation (1) ...". If you use the abbreviations "Eqn" or "Eq." and "Eqns." or "Eqs.," do so consistently. Place each equation on a separate line. Unless the equation is universally well known or very short, division should be shown on two separate lines. Equation should appear in an appropriate manner. Notice the following examples:

Notes for Quotations

Direct prose quotations of three typewritten lines or less should be incorporated into the text, enclosed in double quotation marks. Prose quotations which exceed three lines should be set off from the text in single spacing and indented in its entirety at least four spaces from the left margin, with no quotation marks at beginning or end.

Notes for Footnotes and Endnotes

Notes may be in the form of footnotes, placed at the bottom of each page, or endnotes, placed at the end of each chapter or at the end of the report before the references.

Footnotes and endnotes should be single-space within, and double-space between, each listing. If placed at the bottom of each page, footnotes must be separated from the text by a complete horizontal line single space above the first line of the foot note and must be written using a smaller font size.

Arabic numerals, asterisks or small letters should be used for footnotes and endnotes. In either case, the label used may appear either above the line or in parentheses even with the line.

Web address of a web document should be given in the form of footnotes, placed at the bottom of each page, wherever it is needed. The details of the web document e.g., retrieved date, should be given in REFERENCES.

Discussion: Discussion of the overall design process and tasks. You should also discuss all your experiences during manufacturing, your objectives before manufacturing, and how many of these objectives could be met after manufacturing. Discussion should also include the effects of your design on environmental issues.

The heading should be centered between the text margins 5 cm from the top of the page; the title goes two line spaces below. The text begins at least three line spaces below.

Conclusion: Give the conclusions derived from this design study.

The heading should be centered between the text margins 5 cm from the top of the page; the title goes two line spaces below. The text begins at least three line spaces below.

Acknowledgments: List individuals and/or companies that provided support in the way of equipment, advice, money, samples, etc.

References: All references given in this section should be cited within the main text. IEEE format should be used.

Appendices: (Make sure that all the material given in the Appendix is cited in the main text.)

Additional Figures: Figures, performance curves, design computations (in detail) which have not been given in the main text.

Catalogues: Copies of catalogues and literature used in the design.

User's Manual: Give operation and maintenance manual for the system.

Format of the interim report should be same as the format of previous report templates.

SOME USEFUL HINTS FOR PROJECT REPORT

- *You are welcome to ask any question to your project supervisor and course instructor about the projects and project reports during the office hours.*
- *Do not use first person pronouns (I, We) in your sentences in the text.*
- *Number all of the pages. Place the page numbers at the bottom of the page.*
- *All of the figures and tables in the text should be numbered and cited within main text. Figure and table captions should not be avoided.*
- *Engineering drawings should be numbered in a systematic manner. Workshop drawings must have sub-numbers according to the assembly drawings.*
- *Each section and chapter should start on a new page. The titles and subtitles should be clearly differentiated. Each chapter and its sections must also be numbered.*
- *Give just sufficient information for an understanding of the design. NO MORE NO LESS.*
- *Give the reference list at the end of the main text and refer the references by their corresponding reference number as [5], [12] etc. References should be given in the following format:*

  > *AUTHOR'S NAME, "Title of the Book or Paper," Name of the Periodical or Publisher, Volume, Date, Page.*

- *Summarize the results of design computations in tables and indicate which dimension or material (or any other property) you have determined by the result obtained. Remember that every calculation must correspond to a parameter and it must be shown as a figure on the engineering drawing. If you cannot do that, your design calculations are probably not necessary.*
- *Approach the design in a systematic order. Start from the general system, proceed to the subsystems, consider each subsystem as a separate system and obtain new subsystems until you end with known machine elements. Computer-aided design and drafting is required.*
- *All of the machine elements must be designed and selected according to Turkish Standards. If a standard is not available, ISO and then the standards of other institutions are recommended. If no standard is found, apply one of the must common methods of designs.*
- *USE TURKISH STANDARD (TS-2040, 1882, 3004, 1498, 1503, 2 and others) IN ENGINEERING DRAWINGS. Drawings which are not drawn according to these standards will not be considered in grading.*

REMEMBER that...

- *No medical reports or excuses will be accepted for late report submission, competition day or jury.*
- *Full attendance of the project group is required for the competition and the jury.*

LITERATURE SURVEY

KEYWORD: <Keyword 1>, <Keyword 2>, ...

I.4. INTRODUCTION

You are expected to conduct a comprehensive survey on existing products, previous studies and designs, state-of-the-art and patents that will guide you in your design process. Explain which relevant fields are surveyed and the corresponding reasons.

I.5. COMMERCIAL PRODUCTS

Take a look at the available commercial products relevant to your project. Elaborate the following features for these products.

- Operating principles

- Key functional elements such as sensors, actuators, certain machine components / mechanisms

- Cost and market availability

- ...

If there exists more than one commercial product, make sure to include a comparison table to compare their attributes within the framework of the above mentioned features as well as the features you deem necessary.

I.6. STATE-OF-THE ART ON RELATED TECHNOLOGIES

In this section, you are going to take present any relevant technologies that might contribute towards solving your design problem. These technologies include but not limited to actuators (e.g. [1]), sensors, mechanisms, circuit components, etc. You should also research the literature for previous studies and designs that seem relevant to your design objectives. State their advantages and disadvantages and compare the available solutions. Give a sound discussion on the previous work and indicate their performance.

I.7. PATENT

List all pertinent patents (e.g. [2]) in a categorized fashion in this section. Do NOT put the whole patent document but include if necessary the schematics and related claims from the patent followed with your comments about the significance of this document for your design.

I.8. SUMMARY AND CONCLUSION

Mention the total number of products and patents presented in this report. Briefly explain the potential contribution / inspiration provided by this survey towards creating alternative solutions for your design.

I.9.   REFERENCES (This is an example of a references section. Put all the references at the <u>end of the report</u>.!!!)

[1] http://www.maxon.com last viewed on March 3rd 2009.

[2] D. R. McMortry et.al. "Touch Probe", US-Patent 5669152, 1997.

<u>*Important notes on this report:*</u>
- *Popular websites for patent survey:*
  - *ep.espacenet.com*
  - *www.uspto.gov*
  - *www.delphion.com*
  - *www.dialog.com*
  - *www.tpe.gov.tr*
- *Use this document as the template and follow this format (margins, line spacing, fonts, font sizes etc.).*
- *Pay extra attention to the content of this document.*
- *In writing this report use your own expressions and make sure that the text flows in a logical order.*
- *All tables and figures should have proper captions and must be referenced in the main text.*
- *Cite references where necessary. Do not place any references in the References section unless it is cited within the main text.*
1. *Do not exceed 10 pages for this section and use the pages efficiently.*

PROBLEM DEFINITION AND DESIGN SPECIFICATIONS

This report should include a brief introduction to the design problem. It should provide a clear and detailed statement of the design problem and define overall project goals. Make sure to elaborate on reasons for the need of this design. Based on your survey of past work on the subject, state your design specifications and determine your design criteria. Define performance targets for the product to be designed. Define design constraints if there are any. Your final design must satisfy these specifications and the design should be carried out according to the selected design criteria. Use the similar documents for former ME 407 design project examples, which will be available to you, as a guide to prepare this portion of the report.

I.10. PROBLEM

Clearly define the problem. It should provide a clear and detailed statement of the design problem and define overall project goals. Make sure to elaborate on reasons for the need of this design.

I.11. CUSTOMER REQUIREMENTS

Customer requirements will be identified. The following table can be used as a guide to define the customer requirements.

Dimension	Description
Performance	The primary operating characteristics of the product, expressed in measurable quantities and ranked objectively.
Time	All time aspects of the design
Cost	All monetary aspects of the design
Features	Characteristics specifying basic functions
Reliability	The probability of failure of the product within a specified time period
Durability	Expected time of use before the product breaks down and replacement is preferable to continued repair, a measure of product life
Serviceability	Ease of repair and time to repair after breakdown.
Conformance	Degree to which the product meets customer expectations and standards
Aesthetics	How the product looks, sounds to customer

Customer requirements will be classified in three groups:

Expecters: Basic attributes that the customer expects to see in the product

Spokens: Specific features that the customers want in the product

Unspokens: Attributes that the customer does no talk about but remain important to the customer

Exciters (Delighters): Features that are not known by the customer and make the product unique and distinguish from competitor

I.12. BENCHMARKING (EVALUATION OF COMPETITION)

- Determine features and functions that are most important to the end user

- Determine features and functions that are important to technical success of the product

- Determine functions that markedly increase the cost of the product

- Determine features and functions that differentiate the product from its competitors

- Determine functions which have greatest potential for improvement

- Establish metrics for evaluation

- Evaluate the products and its competitors using performance testing

- Generate benchmarking report

I.13. ENGINEERING CHARACTERISTICS

It will include the parameters, design variables and constraints that you have collected through research, including benchmarking and reverse engineering activities. They will be complete after creating House of Quality in the step of Quality Function Deployment.

I.14. QUALITY FUNCTION DEPLOYMENT

Using the Quality Function Deployment (QFD) spreadsheet template, fill in the file. Summarize and assess the results here. Give the QFD output as an annex. Revise engineering characteristics; establish design criteria, performance targets and design constraints.

I.15. PRODUCT DESIGN SPECIFICATIONS

PDS is the basic *control and reference document* for the design and manufacture of the product. It contains all the *facts* related to the *outcome* of the product development. It will *evolve* and *change* as the design progresses.

You will have to *revise your R2* which is *in effect* a baseline for *PDS.* Rearrange all the information generated above under the headings given below.

Product Identification

- Product name

- Basic functions of the product

- Special features of the product

- Key performance targets (power output, efficiency, accuracy)

- Service environment (use conditions, storage, transportation, use and predictable misuse)

- User training required

Physical description

- What is known (or has already been decided) about the physical requirements for the new product?

- Design variable values that are known or fixed prior to conceptual design process (e.g. external dimensions)

- Constraints that determine known boundaries on some design variables (e.g. upper limit on acceptable weight)

Financial requirements

- **What are the assumptions of the firm about economics of the product and its development?**

- **What are the corporate criteria on profitability?**

- **Pricing policy over life cycle (target manufacturing cost, price, estimated retail price, discounts)**

- **Warranty policy**

- **Expected financial performance or rate of return on investment**

- **Level of capital investment required**

Life cycle targets

- **What targets should be set for the performance of the product over time? (This will relate to the product's competition)**

- **What are the most up-to-date recycling policies of the corporation and how can this product's design reflect those policies?**

- **Useful life and shelf life**

- **Cost of installation and operation (energy cost, crew size, etc)**

- **Maintenance schedule and location (user-performed or service centered)**

- **Reliability (mean time to failure): Identify critical parts and special reliability targets for them**

- **End-of-life strategy (percent and type of recyclable components, remanufacture of the product, company take back, upgrade policy)**

Social, political and legal requirements

- **Are there government agencies, societies, or regulation boards that control the markets in which this product is to be launched?**

- **Are there opportunities to patent the product or sum of its subsystems?**

- **Safety and Environmental regulations. Applicable government regulations for all intended markets**

- **Standards. Pertinent product standards that may be applicable**

- **Safety and product liability. Predictable unintended uses for the product, safety label guidelines, applicable company safety standards.**

- **Intellectual property. Patents related to the product. Licensing strategy for critical pieces of technology.**

Manufacturing Specifications

- **Which parts or systems will be manufactured in-house?**

- **Manufacturing requirements. Processes and capacity necessary to manufacture final product.**

- **Suppliers. Identify key suppliers and procurement strategy for purchased parts.**

EXAMPLE:
PROJECT – HAPTIC HAND DEVICE FOR REMOTE PRECISION MEASUREMENT
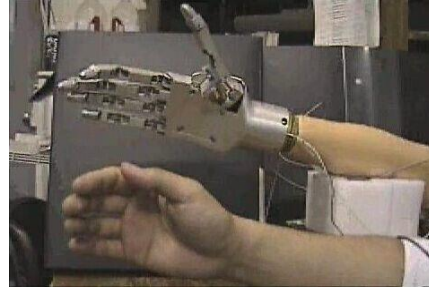
Definition of the Problem:

Haptic interfaces, which present force and tactile feeling at human fingertips, are utilized in the area of tele-manipulation of robots, simulation and design in virtual reality environments, educational training, and so on. Teleoperation is a key technology for robotic surgery, underwater operations, nuclear inspections and space operations. On the design of haptic machines one important field where we need more knowledge is the limits of human perception in grasp tasks.

In this particular project the students are required to design a haptic hand device for remote precision measurement. This hand should be able to measure a certain dimension of an object at a certain precision.

Design Specifications:

- The slave hand should be remotely operated.

- There should be some kind of user interface.

- The minimum accuracy of the resulting measurement should be at least ± 0.1mm.

- There should be a master device that controls a slave hand by some kind of communication.

- There should be at least two fingers to measure the object.

- There should be at least 1 degree-of-freedom force feedback on the master device.

- The user should be able to feel the rigidity of the object.

Specifications for the Model

- Model is to be built on a 1:1 scale

Design Criteria

- Accuracy, precision (25%)

- Fast operation (20%)

- Force feedback (20%)

- User interface design (20%)

- Communication technique (15%)

Performance Targets:

- Accuracy, precision: maximum ±0.1 mm

- Fast operation: minimum speed of 5 m/s

Design Constraints:

- Cost of the product should be less than 1000 USD.

- From design to marketing time should be maximum 10 months.

- Weight of the product should be less than 0.1 kg.

QFD EXAMPLE:

Relationship legend:
⊙ = 9
○ = 3
Δ = 1

Now legend: 1 = very bad, 5 = very good. ▶ Colub, ■ Deltor

Direction of improvement / units per How column:
- Seat width relative to frame width: ↑ (%)
- Steps to adjust seat height: ↑ (steps)
- Force to adjust seat height: ↓ (N)
- Force to slide 95% male passenger: ↓ (N)
- Lifting force required for agent: ↓ (N)
- Push force over 2 cm bump: ↓ (N)
- Force to push aisle chair: ↓ (N)
- Time to transfer between seats: ↓ (sec)
- Fore/aft tipping force at handles: ↑ (N)
- Side tipping force at handles: ↑ (N)

What			Passenger	Agent	Seat width relative to frame width	Steps to adjust seat height	Force to adjust seat height	Force to slide 95% male passenger	Lifting force required for agent	Push force over 2 cm bump	Force to push aisle chair	Time to transfer between seats	Fore/aft tipping force at handles	Side tipping force at handles	Now (Colub ▶ / Deltor ■)
Transfer from personal to aisle chair	Aisle chair preparation	Easy positioning of seat height	4	4		⊙	⊙								▶2 ■3
		Easy to position chairs	6	10	⊙										▶2 ■2
	Passenger movement	Minimum effort for all	15	10				⊙	⊙						■2 ▶3
		Good lifting position	10	12	○										▶4 ■5
		Minimum time for transfer	3	14	Δ							⊙			▶2 ■2
Aisle chair movement		Easy to move	7	8						⊙	⊙		○	○	■2 ▶5
		Fits in aircraft aisle	-	-											▶3 ■4
		Good stability	24	10									⊙	⊙	▶1 ■2
Transfer from aisle chair to seat	Aisle chair preparation	Aisle chair close to aircraft seat	6	2	⊙										▶3 ■3
		Easy positioning of seat height	5	8		⊙	⊙								▶4 ■4
	Passenger movement	Minimum effort for all	15	12		○	○				⊙				▶2 ■3
		Minimum transfer time	5	10		Δ						⊙			▶2 ■3
Importance (Passenger)			10		9	8	9	9	4	14	5	16	16	
(Agent)			11		13	11	7	7	5	14	16	8	8	
Colub			85		2	3	20	15	11	7	15	20	15	
Deltor			87		3	5	27	25	22	15	18	15	10	
Target (Delighted)			90		1	2	20	10	8	7	15	15	10	
Threshold (Disgusted)			85		2	4	25	15	12	10	18	20	12	

PDS EXAMPLE:

**PDS for Compact Disc Jewel Case after the Problem Description
and Need Identification Steps Are Complete**

Product Design Specification

Product Identification

- Compact disc jewel case
- Function: store and protect CDs
- Special features:
  - Stackable
  - Waterproof
  - Scratch resistant
  - Survive drop from 3 ft w/o opening or cracking
- Key performance targets:
  - Hold 1 CD securely when moved by hand
  - Display liner notes
  - Produce audible "snap" when closed
- Service environment:
  - Classroom and home office conditions
  - −20 to 120°F, 100% humidity
- User training required: None

Market Identification

- Market Size: 500 Million units/year in USA
- Anticipated market demand:
  - 5% Share by Year 2 (25M units)
  - 25% by Year 5
- Competing products: Start up venture
- Branding strategy: New Company CD-EASE brand

Key Project Deadlines

- Time to complete project: 6 months

Physical Description

- External dimensions: $5.5 \times 4.9 \times 0.4$ inches
- Include the standard "rosette" feature to hold the CD in place within the case
- Surface texture should be as smooth as the standard CD case on the market
- Include rounded corners and case edges to improve the feel of the case
- Material: TBD but transparent on both broad surfaces to display CD markings
- All others TBD

Financial Requirements

- Time to complete project & key project deadlines: 6 months
- Pricing policy over life cycle: Bulk pricing: $ 0.15 in lots of 25
- Warranty policy: None
- Expected financial performance or rate of return on investment: 21%
- Level of capital investment required: TBD

Life Cycle Targets

- Useful Life: 1000 cycles of opening and closing

Social, Political, and Legal Requirements

- Safety and environmental regulations. Applicable government regulations for all intended markets.
- Standards. Pertinent product standards that may be applicable (Underwriters Laboratories, OSHA).
- Safety and product liability. Predictable unintended uses for the product, safety label guidelines, applicable company safety standards.
- Intellectual property. Patents US 4613044, US 5450951, and US 525451 for the rosette positioning feature.

Manufacturing Specifications

- Manufacturing requirements: Use 50% Made-in-USA parts and 100% USA labor
- Suppliers: TBD all manufacturing will need to be contracted with suppliers.

PROJECT PLANNING and MANAGEMENT REPORT

I.16. INTRODUCTION

In this report, you are expected to explain about the organization of your project, in which fashion did you prefer to distribute the tasks along with your timeline. In the introduction part you should make a brief introduction (3-4 sentences would suffice).

I.17. ORGANIZATION OF THE PROJECT

Task definitions and distribution of workload among the team members should be discussed in this section. As a suggestion, 5 main tasks are presented below. Feel free to modify these tasks. Make sure that you define appropriate subtasks as necessary. Note that you should include the initials of the team members in parentheses so as to show which team member(s) is responsible from that task. Also, the number of subtasks is not limited to what we present below; you can add more subtasks or reduce them.

Here, let us assume that there are 5 team members which will be referred to as TM1, TM2, through TM5. Indicate who is the project manager, who is responsible for coordination. State the responsibilities of each member.

I.18. EXPLANATION OF THE TASKS AND THEIR DEFINITIONS

1. Literature Survey

A general explanation of the task is required here.

> 1.a. Subtask1 (TM1,TM3)
> Define the subtask and explain it, state the objectives for each subtask, estimate how many days it will take to complete this task, name the dates and explain which team members will be responsible from which part of the task, and develop a sequence of the subtasks.

> 1.b. Subtask2 (TM2,TM5)
> Same as above (SAA).

> 1.c. Subtask1 (TM4)
> SAA

2. Conceptual Design

A general explanation of the task is required here.

> 2.a. Subtask1 (TM1,TM3)
> SAA

> 2.b. Subtask2 (TM2,TM4, TM5)
> SAA

3. Detailed Design

A general explanation of the task is required here.

> 3.a. Subtask1 (TM1,TM2)
> SAA

3.b. Subtask2 (TM3,TM5)
SAA

3.c. Subtask1 (TM4)
SAA
4. Virtual Reality Mock-up Model

A general explanation of the task is required here.

4.a. Subtask1 (TM1, TM2, TM3)
SAA

4.b. Subtask2 (TM3,TM5)
SAA

4.c. Subtask1 (TM3, TM4)
SAA
5. Manufacturing

A general explanation of the task is required here.

5.a. Subtask1 (TM1, TM2, TM3)
SAA

5.b. Subtask2 (TM3,TM5)
SAA

5.c. Subtask1 (TM3, TM4)
SAA 5. Documentation
6. Testing

A general explanation of the task is required here.

6.a. Subtask1 (TM1, TM2, TM3)
SAA

6.b. Subtask2 (TM3,TM5)
SAA

6.c. Subtask1 (TM3, TM4)
SAA
7. Documentation

A general explanation of the task is required here.

7.a. Subtask1 (TM1,TM2, TM3)
SAA

7.b. Subtask2 (TM2,TM5)
SAA

7.c. Subtask1 (TM1,TM3,TM4)
SAA

I.19. TIME TABLE

This is going to be a tabulated form of what you explained above. Any other relevant explanations should be included as well.

Table 1. Time table showing the overall distribution of the workload

TASK ID	DURATION (# WEEKS)	TEAM MEMBERS
1.a	1 week	TM1,TM3
1.b	2 weeks	TM2,TM5
1.c	4 weeks	TM4
...	...	...
5.a	4 weeks	TM1,TM2,TM3
5.b	1 week	TM2,TM5
5.c	2 weeks	TM1,TM3,TM4

I.20. TIMELINE

Here you should present a detailed Gantt chart showing all the tasks and subtasks with their timeline represented as bar graphs similar to the one shown in Figure 1. Note that documentation, i.e. reports, should be properly placed at their respective dates. You may use "Microsoft Office Project" application program for preparing the Gantt chart.
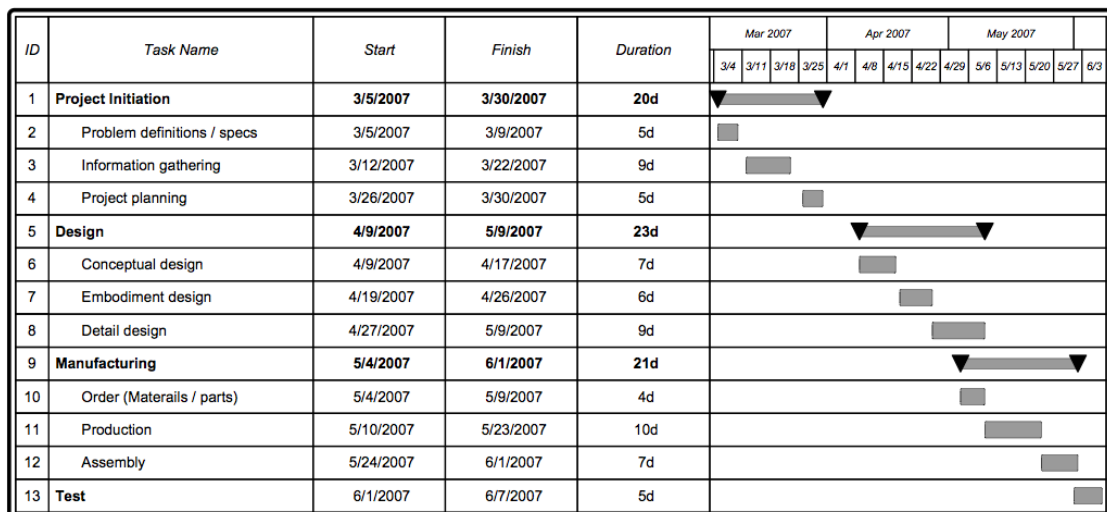
ID	Task Name	Start	Finish	Duration
1	**Project Initiation**	**3/5/2007**	**3/30/2007**	**20d**
2	Problem definitions / specs	3/5/2007	3/9/2007	5d
3	Information gathering	3/12/2007	3/22/2007	9d
4	Project planning	3/26/2007	3/30/2007	5d
5	**Design**	**4/9/2007**	**5/9/2007**	**23d**
6	Conceptual design	4/9/2007	4/17/2007	7d
7	Embodiment design	4/19/2007	4/26/2007	6d
8	Detail design	4/27/2007	5/9/2007	9d
9	**Manufacturing**	**5/4/2007**	**6/1/2007**	**21d**
10	Order (Materails / parts)	5/4/2007	5/9/2007	4d
11	Production	5/10/2007	5/23/2007	10d
12	Assembly	5/24/2007	6/1/2007	7d
13	**Test**	6/1/2007	6/7/2007	5d

Figure 1. Sample Project Gantt chart

I.21. SUMMARY AND CONCLUSION

In this section you should discuss several important points of your reports such as,

- Risky tasks and possible backup plans,

- Technologies and/or software/hardware tools that are going to be utilized in the design process.

Important notes on the report:

   o *Use this document as the template and follow this format (margins, line spacing, fonts, font sizes etc.).*
   o *Pay extra attention to the content of this document.*
   o *In writing this report, use your own expressions and make sure that the text flows in a logical order.*
   o *All tables and figures should have proper captions and must be referenced in the main text.*
   o *Cite references where necessary. Do not place any references in the References section unless it is cited within the main text.*
   1.1. *Do not exceed 6 pages for this section and use the pages efficiently.*

CONCEPTUAL DESIGN

I.22. INTRODUCTION

In this report, you are expected to explain alternative design concepts you have developed including your evaluation process on these concepts which in turn results in the selection of best concept(s). In this part, you should make a brief introduction (3-4 sentences would suffice) to your conceptual design process.

I.23. CONCEPT DEVELOPMENT AND PRESENTATION

The alternatives you have developed up to now should be presented and discussed in this section. Make sure to decompose your design problem into its functions/elements using physical and functional decomposition paradigms. For each function provide alternative approaches. Hence, a **morphological chart** [1] is to be used for this purpose. The following items should be included:

- Hand-sketches, scribbles highlighting your concept generation process (scanned images are preferred).

- Solid models prepared by using a Computer-Aided-Design (CAD) tool (if applicable).

- Brief explanation of each concept with the emphasis on the rationale (why is this concept relevant for your purpose?).

I.24. EVALUATION OF CONCEPTS

In this section, you are going to evaluate your alternative concepts presented in the previous section. Define a number of metrics (cost, ease of implement, fun factor etc.) that will be used in the evaluation process. You may wish to compare these alternatives objectively using the defined metrics (use of a comparison matrix is recommended such as Pugh's concept selection process, or Weighted Decision Matrix, or Analytic Hierarchy Process).You can use the Excel templates given on the web site of the course in evaluation.

At the end of this section you need to come up with the "best evaluated design." If necessary you may include pre-design (back-of-the-envelope) calculations (such as power, force, torque requirements, space limitations, etc.) facilitating the evaluation process.

I.25. BEST CONCEPT

Once the best concept is identified and objectively verified, you are expected to concentrate on the details of this concept. Making use of the morphological chart you need to identify sub-systems and their alternative components, implementation techniques, etc. Consequently, this chart should assist you in figuring out the best solution serving for your original concept.

I.26. SUMMARY AND CONCLUSION

In this section summarize the key points of your conceptual design and briefly discuss how you will proceed towards the detailed design phase.

I.27. REFERENCES (This is an example of a references section. Put all the references at the <u>end of the report</u>.!!!)

[1] Dieter G.E., Engineering Design, 5/e, pp.226-229, McGraw Hill Boston MA, 2013.

<u>Important notes on the report:</u>

- *Use this document as the template and follow this format (margins, line spacing, fonts, font sizes etc.).*
- *Pay extra attention to the content of this document.*
- *In writing this report use your own expressions and make sure that the text flows in a logical order.*
- *All tables and figures should have proper captions and must be referenced in the main text.*
- *Cite references where necessary. Do not place any references in the References section unless it is cited within the main text.*
2. *Do not exceed 30 pages for this section and use the pages efficiently.*

DETAIL DESIGN

I.28. INTRODUCTION

In this report you are to elaborate the design details. You are expected to make a brief introduction about your design and its various aspects.

II. PROPERTIES OF DESIGNED SYSTEM

Provide the details about the following items:

- Operating Principle: You should explain the operating principle of your final design.

- Important aspects of design: It is expected that your design should not be totally similar to the existing designs. Hence you should highlight the interesting/creative aspects of your design. Describe the operation, maintenance, advantages, disadvantages, limitations to applications, superiority over the previous designs, safety and similar concepts.

- The system and subsystems should be separated into their machine elements (shafts, keys, gears, fins etc.) and their functional requirements should be determined.

I.29. ENGINEERING CALCULATIONS

Present all RELEVANT engineering calculations including material strength, vibration, kinematics, dynamic, heat transfer, aerodynamic etc. (if applicable). Make sure to state the assumptions, modeling simplifications and approximations you have adopted in these calculations.

A systematic classification and approach to the calculations are essential. Geometrical dimensions, materials, stability, performance, machinability and similar parameters must be determined. Give sample calculations only for the design of similar machine elements and subsystems. Summarize the results of design calculations in tables for an easy reference.

Provide the calculations for the reliability of the system. Calculate weight and energy consumption of your machine. Give your predictions for the performance of the machine based on the design calculations.

I.30. ANALYSIS RESULTS

If you have performed some advanced analysis including finite element analysis (FEA), kinematics analysis, dynamic analysis by using software packages (such as Excel, Mathcad, Matlab / Simulink, MARC, ANSYS, etc.) you should provide the results along with your comments on the outputs obtained. Make sure that you relate these analysis results to the engineering calculations you have provided in section III. You may include

relevant program codes in the Appendix. If you provide program codes make sure that this code is properly commented.

I.31. DISCUSSION OF CONTROL ALGORITHMS AND SOFTWARE

In this section, you are expected to give explanations about your control algorithms and software (if applicable) by the use of flow charts and relevant diagrams.

I.32. SYSTEM TO BE MANUFACTURED

You should provide the details about the system that will be manufactured. Make sure that you rationalize your decision about manufacturing. Speculate on why and how the manufactured system can contribute to the evolution of your final design. Refer to the technical drawings of parts and assemblies in the Appendix that were developed for manufacturing purposes.

I.33. DISCUSSIONS AND CONCLUSIONS

In this section, you should give a brief discussion about the overall design. Having completed the detailed design, if you had re-started the design process all over again, how would you have approached the design process?

(This section of will be used to build the Appendix for the Final Report)

APPENDIX

Appendix should include:

•   Engineering Drawings: (Including assembly and technical drawings) Full assembly drawing, several sub-assembly drawings, workshop drawings. Set of given engineering drawings must explain the design in your mind to the reader. Assembly drawings cannot be avoided. Drawings for standard machine elements and subsystems (bolts and nuts, roller bearings, electric motors etc.) should not be given in detail and their workshop drawings must be avoided.

•   Material list: Bill of materials

•   Production Planning: Based on the "Bill of Materials" of the full assembly drawings indicate where and how you are going to manufacture/procure these parts in a tabular form.

•   Computer program codes: Matlab m-scripts, simulink blocks, and Mathcad worksheets, Mathematica, and Excel worksheets, etc.

•   Analysis results: Output for computer analysis that are not suitable to place in the main text.

•   Cost Analysis: Give the detailed cost analysis for the system including all of the required fixed and variable costs such as overhead expenditures, material and labor costs.

-       Other Work: As necessary.