

ME 5243 - Advanced Mechanism Design

Fall 2009

Course Project

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Overview

ME 5243 includes an open-ended project on the topic of advanced linkage design. You choose the specific topic of your project. Most students will design a linkage to meet the requirements of some real-world application. However, you may alternately propose to develop a piece of software to synthesize or analyze linkages, or still some other project relevant to mechanism design. The project will be done in teams of 3 students.

This document summarizes the project expectations. The critical due dates are summarized in Fig. 1. The level of effort expected for the project is explained in Section 1.

You will describe your intended project to us in an initial proposal (see Section 2) and a final proposal (see Section 3). You will submit a progress report at mid-semester (see Section 4).

Your results will be presented in both a written report (see Section 5) and an oral presentation (see Section 6). Most projects will include a model which demonstrates that your final design really works (see Section 7).

The grading basis is given in Section 8. Project teams are explained in Section 9. Some suggestions for succeeding in your project are presented in Section 10. An Appendix includes tips for preparing visuals for your oral presentation.

<u>Item</u>	<u>Due Date</u>
Initial proposal	Monday September 21
Final proposal	Wednesday September 30
Mid-Semester Progress Report	Monday November 2
Final written report	Wednesday December 9
Oral presentations	December 9 & 14 ^a

^aYour team will be randomly assigned a presentation date of either Wednesday December 9 or Monday December 14.

Figure 1: Project Calendar.

1 Level of Effort

Each team member is expected to invest a minimum of 50 hours in the course project outside of class. This is consistent with the project weighting of 30% for a 4-credit class.

Your team's project may be related to the work or research of one of your team members. However, the project effort must be independent of your normal professional obligations or thesis effort. In other words, if you receive credit for the work for your job, research assistantship, or thesis, that disqualifies the work from being counted as project effort. (This is consistent with normal UMN policy for determining effort associated with a course.)

2 Initial Proposal

The initial proposal should explain what you intend to do in your project in approximately one page. At least one figure or sketch should be included. If you are designing a mechanism for some specific application, please describe the application and why a mechanism is needed. Describe any mechanism synthesis or analysis procedures that you expect to utilize in the project. Describe any available software that you expect you may be able to apply to the project. Describe any custom software that you expect your team may develop to solve the problem.

If your project is related to the work, research, or thesis of somebody on your team, clearly explain that relationship. Clarify what should be considered as project effort and why (see Section 1).

3 Final Proposal

The initial proposals will be reviewed and returned to you with comments. We may suggest an adjustment to the topic, a change in the scope, or, occasionally, a complete change of topic. Please understand that does not mean that your initial idea was poor; rather, it only means we have concerns about it meeting the class goals or schedule.

Please address any concerns and submit a refinement of your initial proposal as the final proposal. The final proposal is expected to constitute your "contract" of what you will do for your project. The final proposal should be approximately one page in length.

4 Mid-Semester Progress Report

The purpose of the mid-semester progress report is to provide you with incentive for investing reasonable effort in the project by mid-semester. The progress report should be approximately 2 double-spaced pages in length. Describe any refinements in the topic or scope. Briefly summarize what you have accomplished to date. Identify any key references. Describe your plan for completing the project by the end of the semester.

5 Final Report

The final report should include the following:

1. *Abstract.* The abstract should describe your project goal *and summarize the results* in approximately 200 words.
2. *Contents.* List the title and page numbers of the following sections. If you have multiple Appendices, assign a title to each of them and list them each individually.
3. *Contributions.* All team members are *required* to identify each page that they contribute to the report. This can either be done by including a page-by-page summary of each team member's work in a section following the Contents, or by simply initialing each page in the report itself. Each team member's contribution to the report will be taken as a factor in grading; different team members may receive different grades. Team members who do not identify their contributions will receive *no credit*. No more than five pages of the report should include the initials of more than one team member. Pages in the Appendices must be identified as well as in the main report.
4. *Introduction.* The introduction is your opportunity to sell your project to a person who is unfamiliar with your work. Tell why your design challenge was selected: what need does it fulfill? Discuss the value of your project to society (think big, but don't make claims that will damage your credibility). Put your work into perspective with similar works. What is the value added by your project?

Remember that an outside reader may look no farther than your abstract and introduction. Use these to convince readers that the remainder of your work is worth reading!

5. *Body.* The body should clearly summarize the highlights of your work. The format may vary substantially according to the nature of your project.

If your team designs a linkage for some real-world application, the Body should explain how type synthesis was applied, what dimensional synthesis procedures were used and how the linkage was analyzed. You need not re-develop the class notes when explaining your dimensional synthesis and analysis procedures. Rather, cite your notes or the textbook for that. Please fully describe any extensions or enhancements that you developed which go beyond the class material.

Detailed calculations are normally not appropriate for the Body; they belong in the Appendices.

6. *Conclusion and Recommendations.* Summarize your objectives and your results; emphasize the results. Evaluate the success of your project. Suggest any further improvements that you might include if you had more development time.
7. *References.* List any journal articles, texts, conference proceedings, programs, URLs, or other sources that you used. These references should be cited from the body.

8. *Appendices.* The Appendices may include technical drawings, detailed calculations, computer programs, or any other information that is useful toward re-creating your results. If appropriate, please divide such information into separate Appendices and assign a name to each Appendix.

If your work involves detailed calculations, try to format them in appendix-ready form from the start. Then, assembling the Appendices will simply consist of organizing your completed analyses, rather than having to unproductively re-copy draft work.

If you include output from computer programs, please be sure to highlight the most relevant results and explain their relevance in associated text. Pages of output from a computer program are only useful to readers if their relevance is clarified.

Neatly written hand calculations may be included in the Appendices if appropriate.

6 Oral Presentation

Your team will describe your project to the class during the oral presentation. You are expected to prepare computer-based viewgraphs for the oral presentation. Your team will be allotted 12 minutes total to present your work to the class. Please allow 2 minutes for questions at the end.

Even though each team's oral presentation is limited to 12 minutes, the talk should still include a well-formed introduction and conclusion. Please keep in mind that the other class members may not be familiar with what you have been working on all semester. Therefore, please be sure to provide adequate background in your introduction.

All team members should present within the 12 minute window. Complying with the 12 minute limit is necessary to provide sufficient time for all class members to speak. If your team's talk exceeds 12 minutes, we may have to cut you off to be fair to the other teams.

Please be sure that your presentation software is compatible with the available projection equipment, which will be checked out from MEnet, prior to your presentation.

7 Concept Demonstration Prototype

An exciting aspect of mechanism design is that you can clearly see whether your design functions as intended or not by building a model. If your project addresses designing a mechanism to fulfill some real-world task, we ask you to build a concept demonstration prototype to illustrate its function.

The prototype does not have to be full size, and it does not need to be functional beyond producing the motion specified for your mechanism. You are encouraged to utilize the Mechanical Engineering Student Shop or the Medical Devices Center's shop facilities to build an accurate model.

8 Basis for Grading

The course project counts as 30% of the overall course grade. The following weighting will be used to determine the project grade:

<u>Item</u>	<u>Weighting</u>
Revised proposal	4%
Mid-Semester progress report	10%
Oral presentation	18%
Final report (structure & grammar)	18%
Quality of technical content of oral presentation, final report & prototype (if applicable)	50%

9 Teams

Teams will normally consist of three people. Normally, all members of a team will receive the same project grade. However, if the reports or oral presentation indicate that any team member did not contribute their fair share to the project, we may assign different grades to different team members.

Please contribute to your project team. “One man shows” do not result in good projects; too much work is involved. Participating as a strong team will make the project enjoyable for all members.

I *highly* recommend that *all* team members contribute to *all* steps of the project. Do not plan for a single team member to write the reports or build the model. You will likely not be ready for these steps until the due dates are looming. These steps will be too much work for one person by that time. Organize your team carefully from the start.

10 Helpful Hints

1. *Start by specifying the problem, not the solution.* When you begin your project, you know only a *task* that you want to accomplish. You will *not* know what the optimal solution mechanism will look like until later in the semester.

Designers unfamiliar with formal linkage synthesis techniques tend to start with a solution and search for a problem. That is, they tend to try to adapt a pre-existing mechanism to solving a new task. For example, they may state: “We are going to design a Stephenson I six-bar linkage to...” or “we are going to design a cam-driven mechanism to...” While this “reverse engineering” approach may occasionally work, it can lead to overlooking desirable solution mechanisms. State only the problem that you will solve in your project proposal, then exploit the synthesis methods presented in this class to find the best mechanism to solve it.

2. *Do not design a complicated linkage if a simpler linkage will solve the problem.* The rule of thumb of mechanism design is: “The simpler it is, the better it is.”

If a four-bar linkage and a ten-bar linkage are designed to accomplish the same task, the four-bar linkage is usually a far better solution. While the ten-bar may look fancier,

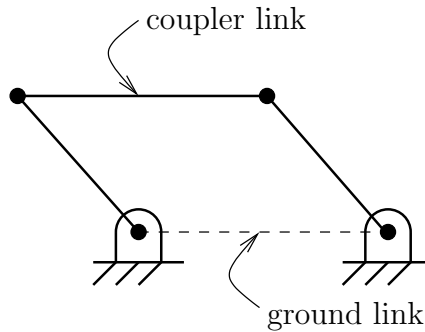


Figure 2: A parallelogram linkage.

it will almost certainly cost more, wear faster, and suffer from more joint slop than an equivalent four-bar mechanism.

Start by trying to find a simple four-bar linkage to solve your problem. Quite often, one can be found, but it can not meet all of the problem constraints. In that case, the added versatility provided by a six-bar linkage, or possibly even a more complicated linkage, is justifiable.

We expect you to try to find six-bar solutions to linkage synthesis problems in this class, as six-bars will likely offer some benefit over four-bar solutions, such as smaller size or better force transmissibility. Nevertheless, you can justify your six-bar by comparing it to the best four-bar that you could find.

Many complex mechanisms exist only because simpler mechanisms could not be found. The synthesis techniques that you will learn in this class greatly improve the chances of your finding a simple solution to an arbitrary problem.

3. *Do not design a parallelogram linkage.* A parallelogram linkage is illustrated in Fig. 2. The linkage has practical value because it is the only four-bar linkage that is capable of moving the coupler link parallel to the ground link. This is desirable if you do not want to tip the load you are moving; for example, a person.

Unfortunately, the coupler link of a parallelogram linkage can only move in a simple arc. Design projects based on this linkage tend to fall in the “solution looking for a problem” category.

We will be describing synthesis strategies which can be used to design six-bar linkages for parallel motion more complex than a simple arc. Such mechanisms are acceptable for this class.

4. *Examples of some “dangerous” (grade-wise) projects.*
 - (a) A mechanism to pour a bottle. (Why do you *need* a mechanism to pour a bottle?)
 - (b) A parallelogram linkage to load a wheelchair on a bus. (The application is well intended. However, synthesizing parallelogram linkages isn’t challenging, and you don’t need synthesis tools to design them.)

- (c) An eight-bar mechanism to do anything. (You can usually find a simpler mechanism which will accomplish the same task better using the methods of this class.)
 - (d) Any mechanism which requires belts, cams, cables, non-circular gears, etc. in the prototype. (Four-bar or six-bar mechanisms will generally provide a much superior solution.) If you have a good reason to include cams or other mechanisms in your project, please discuss your reasons with the instructors first.
5. *Enjoy your project!* Linkage design is a creative and rewarding vocation.

A Suggestions for Preparing Viewgraphs

- *Simplify.*
 - How many words can you *remove* from your viewgraph and still make your point?
 - Communicate a single, clear idea on each overhead.
 - Use keywords instead of sentences.
- *Try to include a graphic on every viewgraph.*

Graphics convey more information than just text. They also help keep the attention of the audience.

- *Put a title on each and every viewgraph.*
- *Make the viewgraph clearly readable from the last seat in the room.*
 - Include no more than six double-spaced lines of text.
 - Limit the length of each line to 45 characters or less.
 - Use a large, boldface font.
 - Use a font larger than 20 points.
 - Make figures and drawing large, simple and clear. Use bold lines.
 - Label axes of graphs with large characters.
- *Make your viewgraphs from clean originals.*

A blurry image will never make a good viewgraph.

- *Standardize.*
 - Stick with a single font style.
 - Try to standardize the size of your artwork.
- *Use contrasting colors.*
 - Black won't be readable on blue, green or red backgrounds.
 - Yellow won't be readable on a clear background.